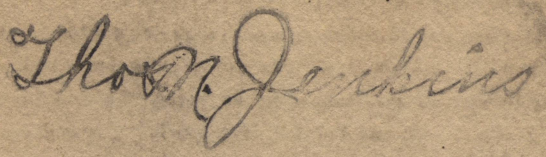
A STUDY IN INCIDENTAL MEMORY



BY

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ARCHIVES OF PSYCHOLOGY

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R. S. WOODWORTH

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CONTENTS

CHAPTER I

PAGE

Introductory 1
Historical 2

CHAPTER II

Incidental Memory for Proportions and Areas of Well-known Objects 16

CHAPTER III

Incidental Memory for Words 44

CHAPTER IV

Letter Square Test 70

CHAPTER V

Further Experiments 95
The Watch Dial Experiment 95
Test of Events with Their Dates 95
Rapid Estimation of the Number of Letters in Words 99
Incidental Memory for Extent of Motion 100

CHAPTER VI

Conclusion 102

BIBLIOGRAPHY 105

A STUDY IN INCIDENTAL MEMORY

CHAPTER I

Introductory

A large amount of knowledge is acquired incidentally. In the development of all mental life this fact plays a most important part. The child exercises the faculty of memory from early childhood, but no one would maintain that it does so with a purpose to remember anything. Its first acts are determined by its physical needs, which awaken instinctive action in response to these needs. As the child becomes adapted to its environment, new experiences arise, and much that was not the immediate object of the child's activity becomes a part of his memory-content. While learning to walk, for example, the child is interested in reaching an objective point or in challenging the approval of nurse or parents, and is not interested in mere walking as such; but, realizing that movements of the limbs, and attempts at balance prove successful, the child casually observes what happened and incidentally associates the successful movement with the result achieved. Most of our habits, whether good or bad, are developed incidentally as by-products to some other habit, act, or condition of the individual. Little progress could be made if it depended upon a "determination to learn."

On the other hand there are myriads of familiar objects and events which occur together in time and place, whose relations have seldom or never been associated in the mind of the individual. When tested for recall of such associations the answers from the average person are very indefinite. This is because the particular relations or conditions to be recalled are not essential to the experience of the individual, and consequently such associations, if formed at all, were so faint as to be wholly or partially lost. This is illustrated by the fact that the most fervent worshipper may not be able to quote a certain prayer he has heard scores of times. Many church-goers can not repeat the particular benediction they have heard pronounced almost every Sunday of their lives. The banker handles money day after day for a life time, perhaps, and most people handle money more or less frequently, but few have a definite idea of the size of a dollar bill or the commonly used coins. Experience teaches one to know what a postage stamp is when it is seen, yet hardly a person

could mail a letter if he were first compelled unexpectedly to represent by a drawing the exact size and detailed features of a postage stamp. People learn to count time by means of a watch or a clock at an early age, but few people of any age know whether the watch with which they are most familiar has Roman or Arabic notation; fewer still can show with any degree of accuracy how these figures appear on the dial. Many things one has said and done, and events that have become thoroughly familiar may not be recalled as attached to any definite date. In case a group of disparate stimuli are presented to the senses, certain qualities about the objects of sense may be accurately perceived, but these qualities may not always be assigned to the special objects to which they belong in the stimuli. We may also have certain prejudice and presuppositions in terms of which many or all of our perceptions are moulded.

All this seems to indicate that objects, relations, and events are perceived in respect to experience and utility, and that only in so far as they have been experienced as such, can they be recalled with any great accuracy. To present evidence in verification of these statements is the purpose of this study.

ACKNOWLEDGMENTS

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HISTORICAL

Only a small amount of literature bearing directly upon incidental memory has been produced, but a great deal has been written during the past ten years that has much in common with this study. Most of the experiments made heretofore have been attempts to show the unreliability of testimony and report, with special reference to the judiciary.

On this general subject W. Stern has contributed more literature than any other single author. Both he and Whipple (82)[1], the latter

[1] The numbers in parentheses refer to the bibliography on page 105.

of whom has written several reviews on the subject, have attributed the original idea of a psychology of testimony to Binet (47), who in the year 1900 stated in his work on "Suggestibilité" the need of such a science. Two years after this publication appeared, Stern began his experimental work on testimony and report. These three writers all give priority in experimental work in this field to Binet and Stern. But it seems that Cattell (34) was the real pioneer in both theory and practise. As early as 1893 he conducted a test on 56 men of the junior class of Columbia College. This was published in 1895 under the title "Measurement of Accuracy of Recollection."

In this test the students were required to answer a series of questions and to state the degree of certainty which they felt in the correctness of their statements: (*a*) to represent absolute certainty; (*b*) tolerable certainty; (*c*) doubt; (*d*) a mere guess. Aside from a number of questions testing common observation there were questions which called for facts that obviously came within the experience of every one of the subjects, such as, the condition of the weather one week previous, weight of their text-book (James's "Briefer Course in Psychology"), the time usually taken to walk from the entrance door of the hall to the door of the lecture room, the distance between certain buildings on the college grounds, a drawing of the ground-plan of the lecture hall, and what was said during the first two minutes of the lecture in the same course one week before.

In answer to the "weather" test, 16 cases may be classified as "clear," 12 "rainy" and 7 "snow," 9 "stormy," 6 "cloudy" and 5 "partly cloudy and partly clear." There was strong tendency to overestimate weight and time. Length was overestimated, but to a less degree. There is also a wide scope of individual differences with reference to the degree of certainty each assigned to his answers. Of the 34 "certain" answers with reference to the weight of the book, 27 were correct and of the 70 doubtful, 37 were correct. "I have found," says Cattell, "that when an observer is entirely doubtful, for example, as to which of the two weights is the heavier, and makes a guess, it is more likely right than wrong."

In the year 1896, a series of questions, fashioned after those of Cattell, was given in the University of Wisconsin by Jastrow to his class in psychology, consisting of 92 men and 26 women. The results of this experiment, as given by F. E. Bolton (50), show a close agreement with the findings of Cattell in respect to accuracy and the high positive correlation of this accuracy with the degree of confidence. The 26 women when compared with an equal number of men show a higher degree of confidence and accuracy with respect to the weather than the men, but the men were more accurate in quantitative estima-

tion and their index of confidence is higher. For both sexes a general overestimation of length and time, and an underestimation of weight were found. These agree with the conclusions of Cattell. No definite correlation with intelligence was observed. During the same year, S. I. Franz and Henry E. Houston (59) applied this series, somewhat modified, to several school children of the various grades. "Taken as a whole," they concluded, "the older children are more accurate than the younger." In other respects their results corroborate those of Cattell.

Four years later (1900) Binet, in his work on "Suggestibilité," reported an experiment on 24 school children. A cardboard 22 centimeters by 15.5 centimeters with six objects fastened upon it furnished the material. The objects were: a postage stamp, a penny, a label, a button, a portrait of a man, and a picture of a group of individuals crowding through a large open gate. The test was given on three different afternoons, the children being tested individually. Each child was told that he would have but ten seconds in which to see the objects and that ten seconds is a very short time; that he must therefore pay very close attention to the objects; that he would have to answer forty questions about the objects afterwards; that he would not be permitted to name the objects aloud while looking at them or to touch them with his fingers. The cardboard was then placed on a table before the eyes of the child. At the end of the ten seconds he was told to name all the objects he saw and to tell all he remembered about them. His answers were written by the experimenter as they were given. Then the questions (interrogatoire) were given, the observer writing the answers as before. In the first report, four children remembered all six objects; but the average number of objects retained was between four and five. Ten forgot one object; eight, two objects, and one three objects.

NUMBER OF TIMES EACH OF THE OBJECTS WERE FORGOTTEN

Stamp 10 times.	Penny 3 times.
Label 9 times.	Portrait 2 times.
Button 4 times.	Picture 3 times.

The author concluded that the order of objects forgotten was determined by the interests of the children. He failed, however, to consider the position of the objects on the card.

Three types of questions (forçage de mémoire) were asked: first, without suggestion; second with moderate suggestions; third with strong suggestions. Binet found that the errors increase rapidly with the increase of suggestiveness. In a later work he found a steady perceptible increase in the resistance to suggestion with age.

This author believed that the real facts of an event which a child has seen can best be acquired by having the child write, while alone, all he remembers of the event. In several places in his "Suggestibilité" Binet emphasizes the importance of psychology in court testimony.

Stern (77, 1, 48), in his first experiment in 1902, used black images of three scenes, namely, an old man feeding a child, a family of dressed rabbits, and a painter moving his household effects. These pictures provide a stock type of experiments which have since been used by scores of investigators. There were 33 subjects—25 men and 8 women—all university students. The pictures were exposed to the whole group for 45 seconds. The first testimony immediately after the exposure Stern calls primary testimony (primäre Aussagen); that given two and three weeks later, he calls secondary testimony (secundäre Aussagen). He asked the subjects to underscore the statements they would take oath to as being absolutely correct. He found that 8.5 per cent. of the statements were incorrect. In the primary "Aussagen," 5.8 per cent., and in the secondary 10 per cent. were incorrect.

Stern concludes from these that after 5 days there is an error of 1.5 per cent.; after 14 days 4.3 per cent., and after 21 days 6 per cent. Time not only weakens but falsifies the memory, and the tendency to error increases about one third per cent. each day. The forgetting by the women is to that of the men as 4 to 3. Men in all make 7.8 per cent. errors and women 10.5 per cent. Twenty-five per cent. were forgotten by the men and 13 per cent. by the women.

The answers "sworn to" contain only one half as many errors as those not "sworn to." The women "swore to" 85 per cent. and the men to 71 per cent. of the answers given. On an average the sworn testimony of the men was 2.1 per cent. false and that of the women 4.8 per cent. The content of the statements were in the following order: personages, actions, objects, spatial relations, number, qualities and colors. Correctly stated they were spatial relations, qualities, objects, persons, actions, colors and numbers.

A few years later the same author, using 47 subjects of both sexes from eight different school grades, averaging six to the grade, and ranging from 7 to 19 years of age, made a contribution to the general methods of studying testimony by using pictures in individual tests. A picture was placed in the subject's hand and he was given one minute in which to observe it and was then asked to describe it orally. "When he began in his account to pause," says Stern, "I said quietely, 'Turn it over in your mind; perhaps something else will occur to you.' At the second pause, 'Nothing more?' When he said 'No' I gave him a list of questions to answer." Two fifths of the

answers were spontaneously given. Six per cent. of these were incorrect. The remaining three fifths had to be brought forth by questioning.

According to Stern, with an average in amount of testimony for girls at 100, the corresponding value for boys is 121; for truth, 99; for spontaneity, 109. The spontaneously correct answers increase very rapidly with age—28 per cent. at seven years; 56 per cent. at 19 years of age. The boys, on the average, named three times as many colors as girls, but the errors for colors were for boys 25 per cent., girls 20 per cent. Resistance to suggestion increases with age, boys being less suggestible than girls.

The author contributes many pages attempting to show types and curves of age and sex differences, though the highest number of subjects for each age is only six, and these are not regularly distributed as to sex. Stern later used colored pictures. The most important one is that of the "Peasant Room" (Bauerstube) given in Stern's "Beiträge," Vol. 12, p. 418. It is described in detail by Colvin (57).

The remaining experiments reviewed in this paper are given virtually in chronological order, and extend up to the present time. The greater part of the work, however, was done prior to 1908.

Litsche (1) had subjects describe a theater scene which they had witnessed. Gross (11) having placed glasses on the table before a class of pupils poured water from one into another, and after the glasses had been removed he asked the pupils to tell the number of glasses that were on the table and which hand was used in pouring the water. The methods of Litsche and Gross gave rise to the so-called "event test" but the results are not of very great importance.

Jaffa (2), before a seminar in the University of Berlin, arranged for a mock fight, to occur at the close of the lecture. Only those participating knew that it was to take place. Of the ten other members of the class present, two men wrote a description of the fight on the same evening on which it occurred, one on the following evening, one six days later, three one week later, and three five weeks later. He concluded that the descriptions written immediately after the fight occurred were in no wise the best. To quote: "The memory consolidates itself more weeks later and gives a vividly truer picture of the events than an enumeration after a briefer time."

Marx Lobsien (7), testing school children from 9 to 14 years of age—164 girls and 205 boys—used two pictures; the first represented twelve familiar objects and the second was the "boy and fishline" picture, which has been frequently used since by other experimenters. It is a colored picture of a boy fishing below a stone bridge over which several men and wagons are passing. Near by, on either side

of the stream, are two houses nestled among some trees and surrounded by a complexity of rural scenery. The pictures were hung on the wall before the children. The first one was exposed five seconds and the second one was exposed two minutes. The children were told beforehand that they would be asked to write from memory what they could see in the pictures. After they had completed the primary "Aussage," 27 questions concerning one picture were asked each subject. This experimenter found that children about 12 years of age see the greatest number of objects. In reference to distance represented by the second picture, more are inclined to underestimate it than overestimate it, girls more so than boys. The girls almost always overestimate the number of trees, houses, etc., but the boys do so less frequently. The "boy and fishline" picture is rather complex and has too many objects represented on a small field of vision to admit of a strictly measurable regularity of report. In this test the pictures were exposed to a large group of children at one time. The inaccuracy of this method is obvious.

Later Lobsien (22) used only one picture containing twelve objects painted on a white card. He had 50 subjects, all boys, who were forbidden to make any movements of the lips while the picture was exposed. Thirty seconds was the time of exposure. They were also informed that they were expected to write what they might see in the picture. He concluded that testimony and report is educable. He was surprised to find that the secondary "Aussage" is often better than the primary "Aussage."

A. Heilberg (9) tested a few maid-servants and workmen on ability to estimate the length of two minutes of time, and to indicate a point 100 steps away, and the number of persons gathered in a church. The answers were so various that no definite conclusions were obtained, but the test, no doubt, afforded a stimulus for similar tests of greater importance.

Wreschner (12, 85), experimenting with pictures on 21 subjects, introduced the "thema" method: instead of the question, for example, "What is the color of the boy's hat?" the mere statement "the color of the boy's hat" was given to the subject as a theme for him to tell or write about. Wreschner criticized the "Verhör" or questionnaire method of his predecessors as being too suggestive. But it has been pointed out by Stern and others that the "thema" method is not desirable, because the subject will turn the theme into a question before answering it. So the method did not gain much favor as such, but in essence it has been frequently incorporated into experimental methods in testimony since Wreschner's work.

Wreschner finds for the primary "Bericht" 88.5 per cent. correct answers, and for the secondary "Bericht" 87.5 per cent.

Up to 1903 great emphasis was placed upon the secondary testimony. Miss Borst (52) says: "But such a procedure does not admit of exact comparison of the influence of time, for it is very probable that the secondary productions are influenced by the preceding deposition on the same object. It is probable that the memories expressed by the witnesses who answer secondarily after eight days are not the memories of the image itself but the memories (verbal or written) of the primary recitation." She further observed that for her predecessors, who generally used the secondary "Aussage," the primary, as a rule, is spontaneous and the secondary interrogative. Certainly these difficulties do not make the primary and secondary testimonials comparable. But while Miss Borst made a good point here, she committed the folly of many of her predecessors by drawing so many general conclusions about sex differences and types of individuals from such a limited number of subjects. She had only 11 women and 13 men—distributed as follows:

1st group 2 women and 3 men.
2d group 1 woman and 0 men.
3d group 3 women and 3 men.
4th group 1 woman and 5 men.
5th group 4 women and 2 men.

Five simple colored pictures, each exposed one minute, were placed under the eye of the individual according to Binet's method. But, improving on Binet, Miss Borst had the testimony, both spontaneous and interrogatory, taken by a stenographer. The advantage of this is evident. She omitted all obviously suggestive questions from the "interrogatoire." The results of this test were:

Persons forgotten 50 per cent.
Objects forgotten 20 per cent.
Qualities forgotten 16 per cent.

With an increase of the interval of time from 3 to 9 days, the fidelity of deposition diminishes, but is greater after three days interval. The tendency to be willing to take oath to answers given increases with time.

In brief she finds that:

Testimony "betters itself" with practise.
Spontaneous is better than "questioned" report.
Women are much more complete and truer than men.

The extent of testimony diminishes with time but the diminution

is stronger for men than for women. Men are less inferior to women in respect to quality than quantity. Women give one third more correct responses than men for the primary Aussage (Recit), and one fourth more for the "Interrogatoire." The tendency to "oath" is notably greater with women and the fidelity accordingly less. The fidelity of the interrogatoire increases with time for the women and diminishes for the men. In 240 reports Miss Borst found only 2 per cent. errorless narratives and .5 per cent. errorless depositions. She conducted the same experiment later on eight girls and eight boys with ages ranging from 6 to 7 years. The exposure in this case was for 90 seconds.

Stern attributes to Michel (34) the credit for first emphasizing testimony of children. Michel flogged a boy before a class of children from 8 to 9 years old, who were then asked to describe the procedure according to questions. They were to place after the answers to the questions the following signals to represent their degree of certainty. r = right, f = wrong, i = I don't know. Objection could be raised here, as the children naturally would not want to write anything wrong. "Guessed" or "I think" might have been better. Eighteen questions were asked as to the number of strokes, length of rod, etc. The results were: correct 47 per cent., false 42.6 per cent., and uncertain 10.4 per cent. In the second test there were fourteen questions asked with regard to the color of wall, number of windows, along with some suggestive questions about the regular class room. All had used the room from three fourths to one and three fourths years. The result was for boys: correct, 50 per cent.; false, 40.75 per cent., and uncertain, 9.75 per cent.; for girls: correct, 51.5 per cent.; false, 41.25 per cent., and uncertain, 7.25 per cent.

Clara and William Stern (23) tested 8 children ranging from $1\frac{1}{2}$ to 4 years, with questions calling up common events in recent experiences, as to what the child had for breakfast, etc.

Rosa Oppenheim (28) performed an experiment on 30 girls from 10 to 12 years of age. She took primary, secondary and tertiary testimonies on March, June and September respectively. In each case the spontaneous testimony (Bericht) was followed by questions (Verhör). She concludes like Lobsien and Borst that children are educable in testimony. They required more time for primary than for secondary and tertiary reproduction. The briefest statements were, as a rule, the most accurate.

Kosog (29, 62), one day, placed near the edge of his lecture desk, so that all could clearly see them, a pen holder, a pocket knife, and a piece of chalk. After the children had left the room at recess he removed the objects. At the beginning of the second hour he asked the

same children what they had seen on the desk during the first hour. Only two of the class of 24 children remembered having seen even the pocket knife. At the close of this experiment the objects were shown to the children and at a later hour these children were asked what they had seen on the same desk during the recitation just previous. None of the objects were on the desk at the time referred to. However,

26 per cent. of the children answered that they had seen the knife.
56 per cent. of the children answered that they had seen the chalk.
63 per cent. of the children answered that they had seen the pen holder.

H. Breukink (39, 17) tested 99 nurses, 69 common working people, and 70 cultured women and men with the picture test after the plan of Miss Borst. With the first picture the test checks up very closely with Stern's results on school children. For Stern, girls answered more than boys spontaneously but erred more. In answer to the questions the opposite was true. In Breukink's tests the educated subjects gave spontaneously from two to three times as many facts, operations, qualities, etc., as the uneducated. The women were more correct in free description and gave more colors than men. In general the color answers were uncertain in both sexes. In answer to questions ("forced memory") men surpassed women in their resistance to suggestion. The answers to suggestive questions increased from 75 per cent. in the first to 78 per cent. in the second and 84 per cent. in the third experiment. The educated were more reliable in their answers to questions, and more educable in testimony than the uneducated. Of the answers "sworn" to, the truth was 30 per cent. higher for the educated than the uneducated subjects. The uneducated "took oath" to three times as many suggestive questions as the educated. The uneducated showed (78 per cent. to 74 per cent.) greater willingness to take oath to statements. Three experimenters found the following figures for willingness:

Breukink,	men 75 per cent.,	women 76 per cent.
Stern,	men 71 per cent.,	women 85 per cent.
Borst,	men 61 per cent.,	women 59 per cent.

These figures are hardly comparable. Breukink received twice as many uncertain as false results, while Stern, Rosa Oppenheim and Rodenwaldt received three times as many false as uncertain.

Breukink asked the subjects to state how long it had taken them (*a*) to make the description, (*b*) to answer the questions. He found a strong overestimation of short time, the women being inclined to overestimate more than the men. The optimum of time estimation

was at 11 minutes. Stern (17) found that the curve from three fourths to one minute has a very rapid fall, representing very strong overestimation and cutting the abscissa at between six and eight minutes. In reference to space he found a general tendency to overestimate between two and three meters, then up to twenty meters to underestimate; but for great distance (137 meters) to overestimate. For objects of average dimension, windows, blackboard, etc., the size is fairly well estimated. Smaller objects, *e. g.*, a book, are somewhat overestimated, larger dimensions, for example, a corridor, are underestimated. The overestimation of the vertical was greater than that of the horizontal. The women tended to underestimate, but their evaluation, on the whole, was as good as that of the men. Stern thus observed an overestimation of vertical distances and a general overestimation of the small, and underestimation of large space. This "central tendency of judgment" seems evident throughout where both large and small intervals are in question.

Hollingworth (96 *a*) by a recognition test with squares on light gray cardboard 2.5 centimeters to 50 centimeters on a side, found that "positive constant error increases as the place of the magnitude in the series descends. . . . From any point of view from which the figures may be regarded, the central tendency is revealed working, however, underneath a general tendency to overestimation."

Kuhlman (99) found by testing six subjects in estimating time-length of various familiar sounds artificially produced that the short sounds were overestimated and the long ones underestimated.

J. H. Leuba (100), from an experiment with artificial stars, concludes that the subjects' memory estimates tend to approach the means of all the different intensities of the original stimuli.

Claparède (55), after lecturing on the chief phases of the psychology of testimony, distributed among his classes a questionnaire, in reference to the room, its windows, dimensions, etc. Seventy copies were distributed and only 45 were returned. A number of days later 54 subjects of the university—41 males and 13 females—representing 14 different nationalities, were given the same test. The males answered 90 per cent. with 22.8 per cent. correct, being superior to women in fidelity. Large space was underestimated, small space overestimated. The women showed a greater tendency to underestimate, the men to overestimate. "There was a general tendency to diminish, to contract and reduce spatial memories, to neglect the unusual and the contingent, and to testify in the sense of the probable."

E. Rodenwaldt (27), experimenting on 50 soldiers, used pictures incident to soldiers' life. After the "Bericht" he gave a list of sug-

gestive questions. The most favorable period of time for exposure of stimuli was from five to ten minutes. His results substantiate those of Stern, Wreschner and Binet.

Jung (97) writes: "After finishing an association experiment I usually add another experiment of a different kind to the so-called reproduction. I repeat the same stimulus-words and ask the test persons whether they still remember their former reactions. In many instances the memory fails; and, as experience shows, these locations are stimulus words which touched on emotionally accentuated complexes, or stimulus-words following immediately after such critical words."

Isabel Wallace (80) first used the term "incidental memory" as applied to the general subject of testimony. The data for her work were obtained in connection with an illustrated lecture. The lecture was attended by the normal-school students and the pupils from the fourth to the eighth grades. Twelve questions as to date and hour of lecture, what kind of day it was, color of the lecturer's clothes, change in the lighting of the hall, decorations of the hall, etc., were asked. The normal-school pupils answered at greater length and in more detail than the grade children. The author pointed out that greater command of language enabled the normal-school pupils to answer more fluently and with a greater degree of accuracy. The following are the general averages:

Normal School	8th Grade	7th Grade	6th Grade	5th Grade	4th Grade
79.17	67.58	64.25	53.17	65.33	63.66

"These show a very slight decrease with grade," says Miss Wallace, "considering that the normal-school pupils and the higher grades have greater ability to reason and also a greater amount of knowledge upon which to rely. They show no remarkable gain in the amount remembered incidentally. The difference in incidental memory seems to be due to a natural individual difference." The author speaks of wide individual differences and quotes a variety of answers to show these differences, but does not give adequate figures.

In a supplementary study, quotations were placed on blackboards which were seen by the pupils every day. Nothing was said about the quotations in the meantime. They were erased after four weeks and the pupils were requested to write them from memory. From the viewpoint of memory the results are of little value, the chief difficulty being the fact that there is no assurance as to whether or not all the subjects read the quotations or whether they had seen them elsewhere. The same difficulty is evident in the first test. Half the questions were such that their answers would depend largely upon the physical

position of the individual during the lecture as well as the individual's attitude.

Hollingworth (61*a*) in studying the effect of caffein on the association of ideas and words with simple objects of experience by applying the Color-naming Test, discovered that "in spite of the fact that the colors had been named 220 times by each subject during the experiment, no one was able to do more than give a few groups of 3 or 4 colors in their proper order, and even the proper location of these groups in the series or on the card was impossible. The assistant who had gone over the test 3,300 times knew scarcely more about the colors than did the subjects themselves. There had been of course no intention to memorize in the test."

E. K. Strong, Jr. (work unpublished), has applied tests in incidental memory to his study of advertising. In one experiment the subject was asked to look in a leisurely way from cover to cover through a current magazine which was given him by the experimenter. A series of advertisements containing a part of the advertisements displayed in the magazine in question was then presented to the subject. He was requested to pick out all those which he recognized as having been seen by him in the magazine, and to place those about which he was 100 per cent. sure in pile No. 1, those reasonably sure (75 per cent. sure) in pile No. 2; those about which he had a slight confidence he had seen, in pile No. 3, and the remainder in pile No. 4.

In a similar experiment 25 "ads" were shown successively to the subject. Then the subject, without knowing the object in view, was given a number of pieces of "ads" which comprised all of the separate parts of the 25 "ads" exposed and of 25 other "ads." The subject was requested to pick out all those details that he recognized as having just previously been seen by him, after the manner indicated above. From data so secured Strong determined what details in any particular advertisement attract the attention and are held in memory.

A number of tests have been made upon pathological cases. The results have not contributed to the general field of testimony but the methods used have been valuable. Necessarily the tests had to be very simple, and from these simple tests more measurable ones were devised for normal subjects.

Marx Rhode (36) tested 46 cases of dementia, epilepsy, paranoia, etc., by having the warden place a watch on the table before them. Later a stranger came into the room, took the watch and put it into his pocket. The first description was called for immediately afterward, the second after 6 days and a third and fourth at various number of days afterward. He found an average loss of 34 per cent.

daily. Stern had found 33 per cent., Borst and Wert, 27 per cent. But these figures can mean little in relation to one another.

Bernstein (45) introduced a valuable test in 1903 for feeble-minded. Bogdanoff (21) applied this test on normals and subnormals. He used 9 simple geometrical figures on cardboard fitted into a frame. There were three rows, with three in a row, and they were exposed for 30 seconds. The subjects were told to study the figures so that after the removal of them, they could pick out the same shape (but smaller) from 25 different figures. There were 55 subjects, 39 men and 16 women. The results were in ratio of correct to false answers as 9 to 1. In no case do the false answers reach one half of the whole number of answers. He later tested a large number of different types of pathological cases with the same method.

In an address at Clark University in 1907, Stern (78 and 57) classified the errors of the witness as follows:

(1) "Errors of apprehension, due to overlooking some of the elements presented; misapprehensions that arise in consequence of expectation or habituation. (2) Errors of memory as such, that arise through the filling of the gaps in accordance with habit. In this form of error only a part of the event was actually experienced, and the rest is supplied in accordance with previous experiences. Errors of memory also arise from the using of verbal expressions in an altered sense, when different accounts of the same event are given at various times after the happening. . . . Errors in memory are also due to the growth of the idea in various succeeding reports, for example, in the first report the witness stated, 'there were two trees'; a week later, 'a grove'; still later, 'a forest.' (3) Errors of phantasy. These include the retouching of the recollection, the unintentional blending of the imagined with the experienced, and the confusion of experiences of different times. (4) Lack of will. The witness has too great credulity, he subjects his knowledge to too little criticism, particularly in dealing with uncertain recollections. He will not attend sufficiently to get a clear apprehension of the facts."

The well-known "Aussage" experiments are rather numerous but as they contribute only a little to the subject at hand, not much space has been assigned to them above, and comparatively few have been summarized. Chief among these are the works of Binet, Stern, Lobsien, Wreschner, Borst, Oppenheim, Breukink, and Claparède, all of whom studied from the viewpoint of testimony. Of this type of experiments Whipple (82) gives a fairly complete summary and the general conclusions of Stern are very clearly set forth by Colvin (57). The results of these "Aussage" experiments have shown many interesting facts, but the stimuli used were generally of such a

nature as not to lend themselves readily to accurate measurements. Consequently the reader of such experiments is burdened with detailed records of individual subjects and, where groups are used, the coarse estimation of results in per cent.'s leads to confusion and does not give facts in terms of definitely objective methods.

The reviewed experiments bearing chiefly upon incidental memory are those of Cattell, Jastrow, Franz, and Houston in testing recollection of common experiences and of objects casually observed; Litsche, requiring a description of a theater scene; Gross's demonstration test and Jaffa's prepared mock fight; collected description of the events and details of a holiday lecture by Miss Wallace; Strong's test in advertisements and the experiments of Michel, Kosog, Clara and William Stern, Breukink and Hollingworth.

CHAPTER II

Incidental Memory for Proportions and Areas of Well-known Objects

The aim of the following series of experiments is to determine with what degree of accuracy the average individual can represent sizes, proportions and details of well-known objects which are seen and used hundreds, and, in many cases, thousands of times by almost every individual. Therefore, the objects chosen to be represented are to be found in everyday usage, viz.: a one-dollar bill, a five-dollar bill, a two-cent postage stamp, and the common coins.

There were 704 subjects—337 men and 367 women. The individual subjects first tested were 55 students of Columbia University—43 men and 12 women. The women were all graduate students pursuing courses in psychology, and 4 were trained psychologists. More than one half of the men were graduate students, all but 13 were students in psychology and 13 were trained psychologists. The next group of subjects consisted of business men and women. There were 29 bankers, all men, and 68 merchants and tradesmen, 56 of whom are men and 12 are women. A group test was made on 36 district school teachers—12 men and 24 women—of a strictly rural community, in Fulton County, Pennsylvania; 58 girls of the Industrial Institute and College at Columbus, Mississippi; 131 subjects—48 males and 83 females—of Jersey City high school; 33 country pupils—17 males and 16 females—of a township high school of Wayne County, Pennsylvania; from the public schools of Royersford, Pennsylvania, a town of 3,000 people:

High school	79, boys 35, girls 44
7th and 8th grades	55, boys 26, girls 29
6th grade	49, boys 26, girls 23
5th grade	63, boys 26, girls 37

From the public schools of Springfield, New Jersey, a quasi-rural community:

High school	24, boys 9, girls 15
3d and 4th grades	24, boys 11, girls 13

The writer conducted all the individual tests and those on the two groups—Fulton County teachers and Jersey City high school. The

girls in the Industrial Institute and College in Mississippi were tested by their professor of science, the Springfield and Damascus high schools by their respective assistant principals; and the Royersford subjects by the superintendent of schools, who is a trained psychologist. All the proxy experimenters are university trained men and women. To all of them the nature and purpose of the tests had been fully explained orally by the writer, and all necessary precautions pointed out. Besides this, detailed written directions were given each experimenter. All were personally interested in the problem and gave assurance of well-controlled procedure.

Method and Procedure

The subjects were each given a piece of plain paper (8×11 inches) and a ruler. After they had recorded their sex and school grade they were asked to draw, as accurately as possible, a representation of the size of a one-dollar bill. They were told that they could correct their drawings as often as they liked, but that nothing might be erased; that in case any corrections were desired the previously drawn part or parts should be merely crossed out. The object of having nothing erased was to give the experimenter a means of determining which way the corrections were made, whether the first drawing was made larger or smaller, and so on for all subsequent corrections. There was no time limit assigned for the completion of their drawings.

Before any drawings were executed the purpose of the test was explained, and no effort was spared to solicit a hearty cooperation on the part of the subjects. They were told that no one who did not care to do so would be urged to take the test. The importance of accuracy and independence was emphasized. Precaution was taken against copying and to this effect the subjects were seated (in case of a group test) as they would be for an examination. No two individuals occupied the same desk and the experimenter and teachers kept a close watch.

Throughout the test the experimenter insisted that he desired only accurate and independent work, assuring the subjects that no other kind of results would be of any value to him at all. They were told that they need have no fear of making a poor record, for the brightest people sometimes do the worst, and that no one could identify their records as no names were given with the drawings.

After drawing the one-dollar bill, they were asked to represent in like manner a five-dollar bill, a postage stamp (colored portion) and to signify by figures their estimate of the number of serrations or "teeth" on each side of the stamp.

Then a cardboard (10 × 8 inches) upon which were drawn 35 circles, was handed each subject and he was told that among the circles were to be found those representing the exact size of a cent, nickel, dime, quarter, half dollar and a silver dollar respectively. These circles were numbered from 1 to 35, in order of their sizes. It was explained that the circles were not drawn around the coins but that they represented the outer edge of the coins. This precaution was necessary as a few subjects in a preliminary test stated that they supposed the circles had been drawn around the coins. The subject was requested to write opposite the names of the respective coins, the numbers of the circles which, in his judgment, represented the size of the respective coins.

These circles ranged in diameter from 9 to 44 millimeters, each diameter being one millimeter greater than the one immediately preceding it. In the preparation of the circles for the test a pair of compasses was adjusted so that each circle was drawn on 150 cardboards before any readjustment was made, thus insuring uniformity as well as accuracy in the drawing of the circles. The smallest coin was represented by the circle No. 9 and the largest by No. 29, thereby furnishing practically equal chances for overestimating the largest and underestimating the smallest, respectively. None of the numbers assigned to the circles was permitted to correctly suggest the value of the coin which the particular circle represented. There was an error of a small fraction of a millimeter, for a few of the coins, since a fraction of a millimeter could not well be provided for in the diameters of the series of circles without making a suggestive gap. The diameters of the respective coins as secured from the United States Treasury Department are as follows: cent, 19.05 mm.; nickel, 21.2 mm.; dime, 17.9 mm.; quarter, 24.25 mm.; half dollar, 30.6 mm.; dollar, 38.1 mm.; while the circles used were 19, 21, 18, 24, 31 and 38 mm. respectively. Aside from this fractional diameters would have entailed a tremendous amount of labor in calculation. In the individual tests which the writer conducted in person, a record was kept of the name, sex, and general character of subjects, with notes on their manner of performance, and their introspections. The one-dollar bill and coin tests were varied: part of the individual subjects after drawing the bill were provided with paper and a pair of scissors and told to cut out a piece of paper the size of a dollar bill. The subject was allowed as many trials as he wished. His drawings of the bill could not be seen in the meantime.

Before choosing the coin sizes from the circles, the subject was provided with a pair of compasses and practise paper, and requested to draw circles representing the above-named coins in order of their

values; to practise as much as he liked and to transfer the desired circles to the regularly used sheet of paper. After laying this paper aside the subjects were asked to "choose" the several coins from the series of circles. The test was begun by merely having the circles "drawn," but at the suggestion of E. K. Strong, Jr., the recognition test was added and finally used alone. It is certainly preferable because of the time saved both in applying the test and in dealing with the results, though there is a disturbing element due to the large number of circles before the eye.

In no case was the subject informed as to whether his drawing was too large or too small, nor was he allowed to check up his own results until all the tests had been completed.

Records from business men and women were desired but great difficulty arose in securing such subjects. It was necessary first to choose only those who handled cash regularly. Data were collected in several small towns where the writer knew business men personally or was assisted in meeting them by the aid of some prominent business man of the neighborhood. Where the experimenter was not known he was suspected or looked upon as a "counterfeiter" or a "crook." Often it took longer to satisfy the curiosity of the prospective subject than to perform the experiment. It was necessary to get the record of all the subjects in a given community within a very short time; for after a subject discovered the immensity of his own errors, his interest was such that he was led to discover how well his friends could do at the test. So it soon was adopted as an amusement in the store and office. Likewise when applied to school children, it was carried home and became table talk and sometimes a parlor game, so that all data from the same system of schools had to be gotten during the same half day.

With business men conditions were very hard to control. If a merchant, for example, while "drawing" a bill or "choosing" the respective coins was interrupted by a customer on whose account he would be compelled to handle cash, his results had to be discarded. More than one record in a business place was not easily secured because prospective subjects were always curious about what was being done, and a mere hint that they could pick up would render them useless as subjects. It was especially hard to control the experiment with the bankers. Most of such tests were made in a room apart from the cash rooms and no records were kept in case the subject could see the objects to be represented after the instructions for the experiment had been given. Two business men were found who knew the exact measurement of the one dollar bill in terms of inches. Their records were not used. Data on the postage stamp were gotten from only 16

business men, owing to the time it took from their work. The experimenter took careful note of the manner in which the stamp was drawn in the individual tests. In every case the subject drew the stamp in its upright or vertical position, the upper edge of the stamp always being parallel to the length of the bill. Furthermore, it was found that the manner in which the figures, indicating the number of serrations, were placed upon the respective dimensions, indicated which way the stamp was meant to be measured by the subject. This rule was assumed in interpreting the group results.

In determining the results of these experiments, all measurements were made in millimeters. The dimensions of the bills and stamp were measured from the middle point in one side to the middle point of the side opposite. From these measurements[1] the area, and the ratio of the length to the width, were computed. The measurement of the diameter of the drawn coins was made through the central point indicated by the puncture made by the point of the compasses. The outside of the circle was considered the limit and only integral millimeters were assigned to the diameters. All computations, however, were made to the tenth of a millimeter. In case of the recognition tests for coins the respective numbers represented definite diameters. For example, No. 10 (the nickel) meant a circle 19 millimeters in diameter. If No. 8 or No. 11 was designated, the errors would be -2 or $+1$ millimeters respectively. The exact dimensions of the one-dollar bill and the five-dollar bill, according to the United States Treasury Department, are 186.235 and 78.25 millimeters for length and width respectively. In the measurements of this test 186 and 78 millimeters were used. The dropping of the fractions does not vitiate the results because the average bill shrinks at least .25 of a millimeter.

For the stamp and the bills the deviation from the standard was determined for each individual measurement. The average of all these deviations gives what is shown in the tables as the average error or A.E. From this A.E. was determined the variation of each subject, the average of which, for each group, gives the results under Average Deviation (A.D.). This was computed from the exact A.E. to a tenth millimeter and the figures under A.D. representing whole numbers are really hundredths or per cents. The average of all the deviations from the standard, considered algebraically, gives the results for the column under Constant Error, or C.E. In computing these "errors" there was no grouping of subjects except where the individual measurements were the same to a millimeter. Therefore the tables of frequency were made up in steps of milli-

[1] A record of all these tests along with the original data is open to inspection.

meters. The number of correct cases, those greater than the standard and those less than the standard, are indicated in separate columns. These evaluations were obtained in like manner for the area and ratio of the stamp and bills.

The One-dollar Bill

According to Tables I. and II. there is not a single positive C.E. group, but every group shows a large negative C.E. for the dimensions, area and ratio. This means that there is a universal tendency to strongly underestimate the size of the one-dollar bill, and more so proportionally for the length than for the width. Fourteen subjects overestimated the length as against 688 who underestimated it, while for the width the figures were 63 to 641. Just why both dimensions should be so uniformly underestimated is not so obvious, but it seems reasonable that the error for the length is proportionally greater than that for the width of a one-dollar bill, in view of the fact that the width of a bill is ordinarily perceived in its entirety while the complete length is seldom perceived, owing to the customary manner of folding and crumpling the bill.

Of the 704 subjects, only two cases (two women) were exactly correct for length; no cases correct for width and area, and 12 cases —8 men and 4 women—correct in ratio. Five of these were men of the business group. (The last group of the tables is not considered in these measurements.) There are scarcely any plus cases under length (15), a few more under width (73) and a still greater number under ratio; but in no group is the number of plus cases equal to the number of minus cases.

The bankers give the lowest A.E., and the merchant and student groups follow in order of A.E. The Industrial Institute and College, and the Fulton County Teachers groups stand high in accuracy, and, as a rule, the poorest records are found among those of the lowest school group. The rise in accuracy from the lower grades to the high schools is not gradual because there is a fall at the sixth grade and a considerable rise at the 7th and 8th grades. This obtains for both the length and width. (See Figs. 1 and 2.) The 7th and 8th grades are grouped together as are the 3d and 4th grades. This was necessary owing to the limited number of cases for the separate grades. The last group of the tables shows that there is a noticeable improvement in the results of "cutting" the bill, over the records of the same subjects who drew it, but not so much as might be expected. The tendency is for the subject to cut the bill larger than he drew it, but owing to an observation made below, this may be partially due to the growing of the size of the image of the bill, because the drawing test was always made before the cutting test.

TABLE I

THE ONE-DOLLAR BILL

Groups of Subjects	Sex	Total Subjects	Length						Width					
			Correct	Cases +	Cases −	A.E.	C.E.	A.D.	Correct	Cases +	Cases −	A.E.	C.E.	A.D.
Fulton County teachers	M.	12	0	0	12	50.1	−50.1	17.5	0	0	12	11.6	−11.6	7.2
	F.	24	1	0	23	34.7	−34.7	14.4	0	6	18	8.9	− 6.1	4.4
Industrial Institute and College	F.	58	1	0	57	32.0	−32.0	13.4	0	3	55	10.3	−10.0	3.9
Jersey City H. S.	M.	48	0	1	47	31.3	−31.1	13.2	0	8	40	7.2	− 5.8	4.5
	F.	83	0	1	82	36.5	−36.3	13.8	0	13	70	9.3	− 7.9	4.6
Royersford H. S.	M.	35	0	0	35	37.0	−37.0	13.8	0	3	32	13.6	−13.2	6.7
	F.	44	0	0	44	44.7	−44.7	13.9	0	0	44	13.6	−13.6	6.1
Damascus and Springfield H. S.	M.	26	0	1	25	34.9	−34.7	12.5	0	0	26	9.9	− 9.9	6.0
	F.	31	0	0	31	32.4	−32.4	12.0	0	1	30	10.7	−10.2	5.6
All H. S.	M.	109	0	1	108	33.6	−33.5	12.1	0	11	98	10.1	− 9.5	5.6
	F.	158	0	1	157	37.3	−37.1	14.0	0	15	143	10.8	− 9.9	5.6
7th and 8th grades, Royersford	M.	26	0	0	26	47.6	−47.6	17.7	0	0	26	19.7	−19.7	5.9
	F.	29	0	0	29	50.0	−50.0	19.8	0	0	29	19.6	−19.6	6.5
6th grade, Royersford	M.	26	0	0	26	41.4	−41.4	15.4	0	0	26	15.4	−15.4	6.6
	F.	23	0	0	23	46.2	−46.2	11.3	0	0	23	13.6	−13.6	5.8
5th grade, Royersford	M.	26	0	1	25	51.6	−51.3	19.4	0	1	25	21.2	−21.1	7.7
	F.	37	0	1	36	52.9	−52.8	20.5	0	1	36	18.1	−17.8	9.5
5th, 6th, 7th and 8th grades	M.	78	0	1	77	47.3	−47.2	17.7	0	1	77	18.9	−18.9	7.2
	F.	89	0	1	88	50.2	−50.1	18.0	0	1	88	17.2	−17.1	7.9
Springfield 3d and 4th grades	M.	11	0	0	11	59.1	−59.1	12.1	0	0	11	25.8	−25.8	9.1
	F.	13	0	0	13	60.7	−60.7	20.5	0	0	13	18.1	−18.1	4.6
Bankers	M.	28	0	3	25	12.3	−10.8	5.0	0	8	20	5.0	− 2.9	4.3
Merchants	M.	56	0	3	53	19.6	−18.9	10.9	0	7	49	5.5	− 4.1	3.2
	F.	13	0	0	13	24.8	−24.8	15.4	0	7	6	8.1	− 3.4	6.3
Columbia students	M.	43	0	3	40	24.6	−23.7	13.2	0	14	29	6.8	− 3.8	4.5
	F.	12	0	1	11	23.2	−22.7	12.7	0	1	11	6.8	− 6.6	5.0
Columbia bill cut from paper	M.	19	0	6	13	19.7	−15.6	15.0	0	10	9	3.9	− 1.4	3.1
	F.	10	0	2	10	31.0	−11.6	18.0	0	3	7	5.0	− 3.2	2.4

TABLE II

THE ONE-DOLLAR BILL. (*Continued*)

Groups of Subjects	Sex	Total Subjects	Area Cases Correct	Area Cases +	Area Cases −	Area A.E. Sq. Mm.	Area C.E Sq. Mm.	Ratio Cases Correct	Ratio Cases +	Ratio Cases −	Ratio A.E.	Ratio C.E.	Ratio A.D.
Fulton County teachers	M.	12	0	0	12	4495.	− 4495.	0	6	6	37.2	−11.3	25.1
	F.	24	0	1	23	3673.	− 3595.	0	4	20	32.9	−26.0	18.4
Industrial Institute and College	F.	58	0	1	57	3997.	− 3991.	0	18	40	21.8	−11.5	10.8
Jersey City high school	M.	48	0	2	46	3118.	− 3075.	1	8	39	25.4	−21.3	10.7
	F.	83	0	1	82	5189.	− 5053.	0	11	72	27.2	−21.7	11.8
Royersford high school	M.	35	0	0	35	4584.	− 4584.	0	9	26	21.0	− 7.0	11.2
	F.	44	0	0	44	4950.	− 4950.	2	12	30	26.3	−15.4	13.5
Damascus and Springfield high school	M.	26	0	0	26	4075.	− 4075.	0	9	17	24.5	−10.4	14.4
	F.	31	0	0	31	3912.	− 3912.	0	13	18	17.3	−08.0	11.2
Royersford 7th and 8th grades	M.	26	0	0	26	6027.	− 6027.	0	11	15	29.7	−02.1	16.3
	F.	29	0	0	29	5906.	− 5906.	2	10	17	29.9	−08.7	18.0
Royersford 6th grade	M.	26	0	0	26	5401.	− 5401.	0	11	15	32.8	−01.9	17.1
	F.	23	0	0	23	5512.	− 5511.	0	8	15	31.1	−17.6	15.9
Royersford 5th grade	M.	26	0	0	26	6668.	− 6668.	2	9	15	29.8	−12.8	16.6
	F.	37	0	0	37	6416.	− 6416.	0	18	19	37.4	−22.7	25.1
Springfield 3d and 4th grades	M.	11	0	0	11	6671.	− 6671.	0	1	10	36.2	−21.4	32.0
	F.	13	0	0	13	10429.	−10439.	0	6	7	36.0	− 6.1	22.8
Bankers	M.	28	0	7	21	1451.	− 1049.	2	11	15	13.0	−02.1	07.5
Merchants	M.	56	0	4	52	2267.	− 2040.	3	16	36	15.7	−10.2	14.0
	F.	13	0	5	8	2082.	− 1573.	0	3	10	24.1	−19.7	15.7
Columbia students	M.	43	0	5	38	2703.	− 2501.	0	10	33	25.8	−19.3	16.0
	F.	12	0	0	12	2842.	− 2842.	0	5	7	25.5	−07.6	10.2
Columbia cut from paper	M.	19	0	8	11	2143.	− 529.	1	2	16	30.1	−29.3	17.2
	F.	10	0	4	6	3679.	+ 524.	0	6	4	34.0	−07.4	19.8

EXPLANATION OF PLATE I.

FIG. 1. A.E. for length of the one dollar bill.
FIG. 2. A.E. for width of the one dollar bill.
FIG. 3. A.E. for half dollar.
FIG. 4. A.E. for silver dollar.
FIG. 5. A.E. for dime.
FIG. 6. A.E. for quarter.
FIG. 7. A.E. for cent.
FIG. 8. A.E. for nickel.
FIG. 9. A.E. for serrations for length of stamp.
FIG. 10. A.E. for serrations for width of stamp.
FIG. 11. A.E. for length of stamp.
FIG. 12. A.E. for width of stamp.
B.—Bankers.
M.—Merchants.
C.—Columbia students.
H.—High school.
8–7.—Eighth and seventh grades.
6.—Sixth grade.
5.—Fifth grade.
4–3.—Fourth and third grades.

Note.—The base lines represent zero A.E. Scale for the dollar bill, $\frac{1}{3}$ mm.; for stamp and coins, $\frac{5}{3}$ mm.; for serrations, $\frac{2}{3}$ serrations. Solid line, males; broken line, females.

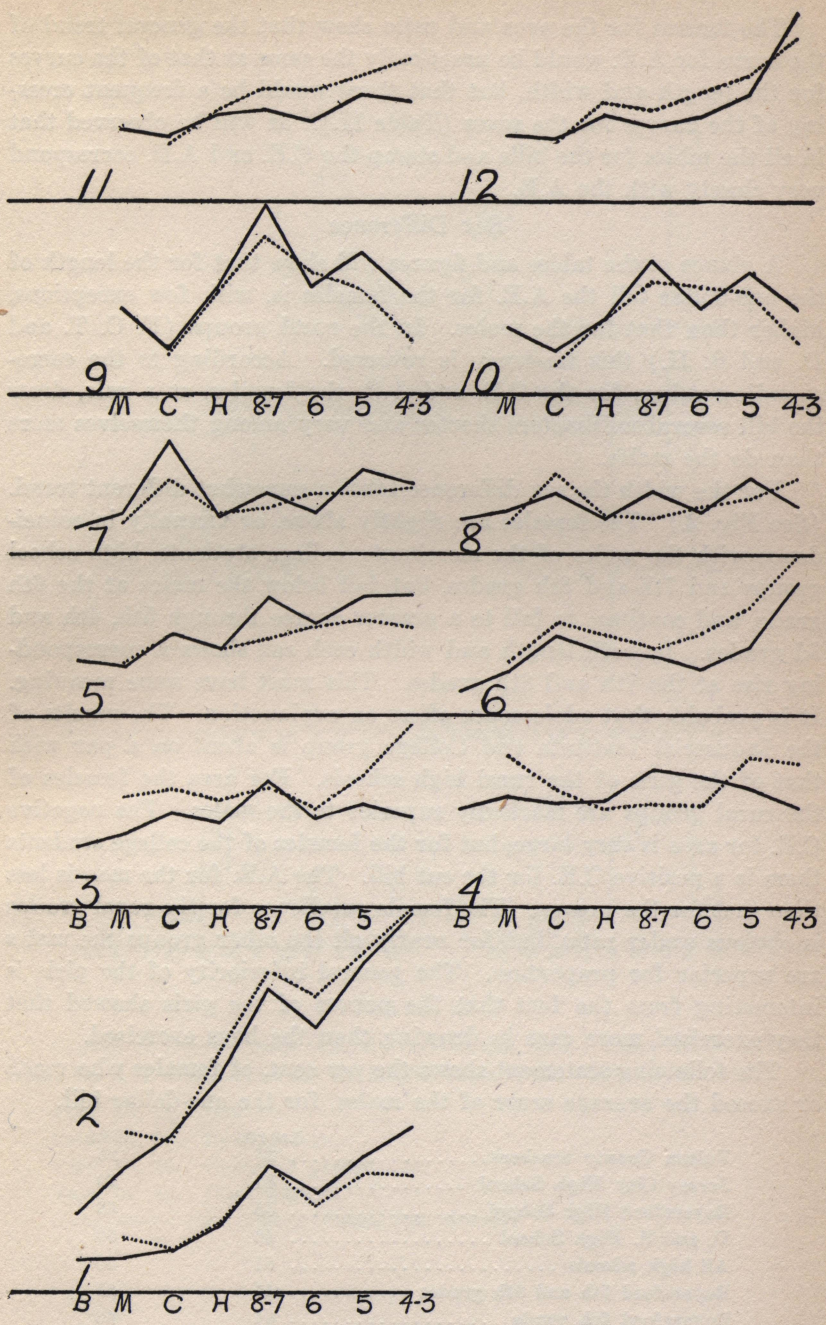
11
12
9
M C H 8-7 6 5 4-3
10
M C H 8-7 6 5 4-3
7
8
5
6
3
B M C H 8-7 6 5
4
B M C H 8-7 6 5 4-3
2
1
B M C H 8-7 6 5 4-3

PLATE I

The figures for the area and ratio show that the general trend of the curve for A.E. would be practically the same as that of the curves for the length and width, but that there would be a frequent crossing of the curves for the sexes (Table II.). It will be observed that in all the tables for the bills and stamp the C.E. and A.D. correspond very closely with the A.E.

Sex Difference

A glance at the tables and figures will show that for the length of the one-dollar bill the A.E. for the females is, with few exceptions, higher than that for the males. In the rural groups (F. C. T. and D. and S. H.) this tendency is reversed. According to the corresponding values for the C.E. and A.D. the females, as a rule, draw the bill several millimeters shorter and vary among themselves more than do the males.

For the width the sex difference takes a somewhat different trend. (See Fig. 2.) The females are slightly above, or virtually in coincidence with the males of the merchants, college students, high school groups and 7th and 8th grades, but fall below the males at the 6th grade, and continue to fall to a greater degree through 5th, 4th and 3d grades. In both length and width each sex shows a corresponding rise at the 7th and 8th grades. This must have some meaning. It is probable that adolescence offers an explanation. The results of the Industrial Institute and College group is about on a par with that of the girls of the rural high schools. For area the females of the rural groups are markedly superior to the males. The negative C.E. for area is very large, but for the females of the college students there is a positive C.E. for the cut bill. The A.E. for the men is less than that for the women. The female excellence for the rural groups is obvious under ratio, but for nearly all the other groups the males are superior for proportion. The general inferiority of the girls is interesting from the fact that the papers of the girls showed that they exercised more care in drawing than the boys exercised.

The following statement shows the per cent. of females who reach or exceed the average error of the males, for the one-dollar bill.

	Length	Width
Fulton County teachers	25	25
Jersey City High School	61	59
Royersford High School	55	59
D. and S. High School	48	60
All high schools	61	55
Royersford 7th and 8th grades	45	41
Royersford 6th grade	61	48
Royersford 5th grade	49	46
All grammar grades, 5, 6, 7, 8	50	51
Merchants	61	31

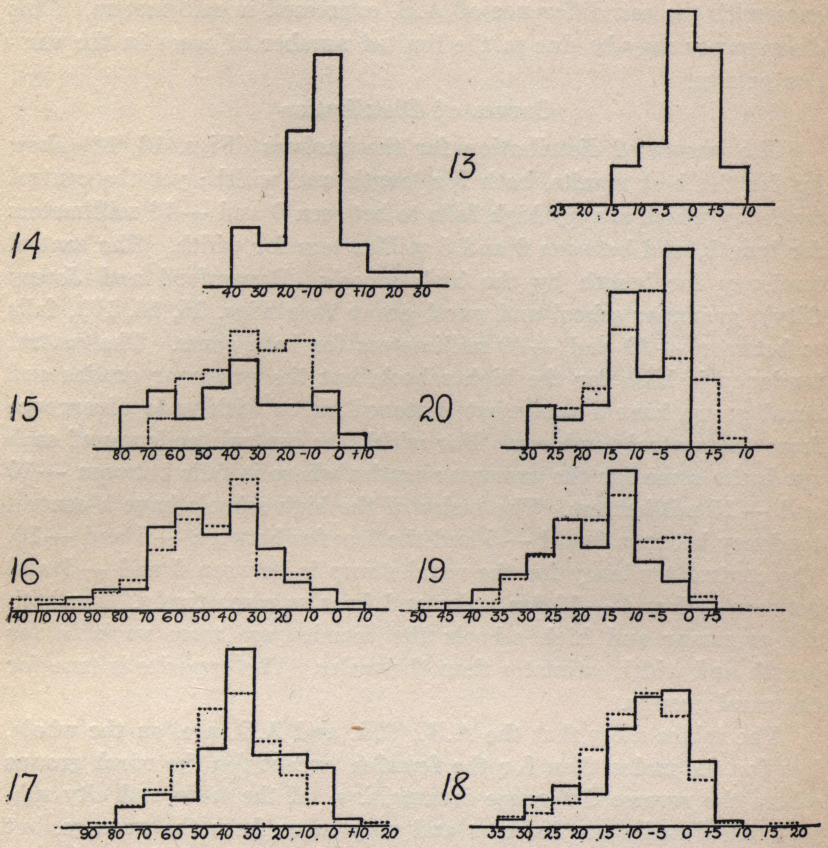

PLATE II

CURVES OF DISTRIBUTION FOR THE ONE-DOLLAR BILL. Those to the left represent the A.E. distribution for the length, those to the right, for the width.

FIGS. 13, 14. Bankers.
FIGS. 15, 20. Rural groups.
FIGS. 16, 19. Grammar grades.
FIGS. 17, 18. High schools.
Note.—Solid line, males; broken line, females.

Comparing these figures with the tables, and the curves, one sees that the difference in average error, between the two sexes, expressed in terms of relative number of subjects, is not wholly in correspondence with the sex difference of A.E. expressed in millimeters. This discrepancy may be due to the limited number of cases in the various groups.

Curves of Distribution

The curves of distribution for the bankers (Figs. 13, 14) show by far the best results, both for length and width; yet the central tendency which is very high falls to between 0 and —10 millimeters for length, and between 0 and 5 millimeters for width. The central tendency for length by the high schools (Royersford and Jersey City), grammar school and rural group (see Figs. 15, 16, 17), falls to between —30 and —40 millimeters for both sexes. The central tendency is high for the high schools but the grammar grades and rural group have a somewhat flattened curve with wide divergence from the central tendency. For width the central tendency of each sex is the same for the grammar grades where it falls between —10 and —15 millimeters. The males of the high schools have a central tendency between 0 and —5 and the females between —5 and —10. The central tendency for the rural group is between 0 and —5 and between —5 and —10 for males and females respectively. For both the grammar and high schools the females are more variable for length and width estimates than the males. The opposite is true for the rural groups.

The tables show that the A.E., C.E. and A.D. are, on the whole, less for the males than for the females, except for the rural groups where the reverse difference obtains, *i. e.*, of the town and city subjects the females are inferior and vary more from the average, but among the rural subjects they are superior to the males and vary less from the average.

Results for the Stamp

A rather large number of correct estimates were made for the dimensions of the stamp (Tables III., IV., V., VI.). Out of 266 men and 349 women tested, 30 men and 40 women gave correct records for the length; and 29 men and 49 women gave correct records for the width. But the correct estimates for the area and ratio are few, as there were but 5 men and 4 women in the case of the former and only 4 men and 5 women of the latter correct. In estimating the number of serrations for each dimension of the stamp, 67 cases—29 males and 38 females—were correct for the length, while for the width 33 cases—16 males and 17 females—were correct. Only 6

cases were correct for the ratio. The area of the stamp is generally overestimated, the length is underestimated, and the width greatly exaggerated. For the estimation of the number of serrations both the length and the width are overestimated. Without exception the ratio of the length to the width of the stamp is too small (see C.E. for respective ratios) while the corresponding ratio for the serrations, with but two groups excepted, is too large. This seems to be conclusive proof that the subject, as a rule, judges the length much better proportionally than he draws it. A large number of cases are found where the subject, whose drawings are square, assigned the greater number of serrations to the vertical side. This discrepancy is perhaps due to the vertical illusion.

On the whole the college students give the best record for width and area. The Fulton County Teachers group is rather low in accuracy for dimensions, while for serrations it is comparatively high. Therefore the country teachers seem to be better for estimating numbers than extent. Reference to the curves, figures and tables will show a rise in accuracy from the grades through the high school to the college group for the dimensions and area of the stamp. This is in keeping with the results for the one-dollar bill. For the serrations, on the other hand, there is a striking exception to this rule. According to Figs. 9 and 10 the college students show the lowest A.E. in estimating the number of serrations. The business men are next in accuracy, and there is a general rise in error from the business men through the high school groups to the 8th and 7th grades, where the highest average error is reached. Then the curve takes a sharp drop at the sixth grade with a gradual fall in the 5th and 4th grade until it almost reaches the level of the college group. The girls of the Industrial Institute and college group, not represented in the curve, are nearly as accurate as the best group (college students).

Sex Difference

With the exception of the 6th grade, the A.E. for the males in estimating both the length and the width of the stamp falls below that of the females. The curve for the girls from the high school to the grades shows a smoother trend than that for the boys. On the other hand, Figs. 9 and 10 show that, with very few exceptions, the females make a smaller A.E. in estimating the number of serrations. This means that the females in estimating length such as that of a postage stamp, as a rule, make greater errors than the males, but in estimating the number of serrations do uniformly better than the males. In view of the fact that most girls write more letters than do boys, the opposite tendency in estimating the dimensions would

TABLE III

The Two-cent Postage Stamp

Groups of Subjects	Sex	Total Subjects	Length						Width					
			Correct	Cases +	Cases −	A.E.	C.E.	A.D.	Correct	Cases +	Cases −	A.E.	C.E.	A.D.
Fulton County teachers	M.	13	1	6	6	2.4	+0.1	1.0	2	9	2	3.5	+2.8	2.2
	F.	24	0	17	7	2.6	+1.7	1.8	0	23	1	4.8	+4.7	2.3
Industrial Institute and College, Miss.	F.	58	8	5	45	3.2	−2.7	2.9	4	29	25	2.8	+0.6	1.9
Jersey City high school	M.	47	4	17	26	2.5	−0.9	1.4	5	28	14	2.6	+1.1	1.2
	F.	80	7	33	40	4.4	−1.4	2.3	16	50	14	2.8	+2.0	2.1
Royersford high school	M.	35	4	5	26	3.1	−2.3	1.6	4	10	21	2.5	−1.0	1.7
	F.	44	9	11	24	2.6	−0.8	2.0	8	25	11	2.6	+1.6	2.1
Damascus and Springfield high school	M.	26	4	12	10	2.7	+0.5	1.9	2	15	9	2.9	+1.4	1.7
	F.	31	6	17	8	3.0	+1.2	2.0	2	28	1	4.2	+4.2	2.3
All high schools	M.	108	12	34	62	2.7	−1.0	1.6	11	53	44	2.7	+0.4	1.5
	F.	155	22	61	72	2.8	+0.1	1.8	26	103	26	3.1	+2.3	2.2
Royersford 7th and 8th grades	M.	26	5	7	14	2.9	−1.0	1.8	5	10	11	2.3	0.0	1.6
	F.	29	5	4	20	3.5	−2.9	2.1	3	19	7	2.8	+1.9	1.7
Royersford 6th grade	M.	26	3	8	15	2.5	−1.5	1.5	3	17	6	2.6	+1.4	1.8
	F.	23	1	10	12	3.5	−0.3	1.6	6	14	3	2.6	+1.8	2.1
Royersford 5th grade	M.	26	2	6	18	4.3	−2.6	2.4	2	14	10	3.4	+0.8	2.2
	F.	37	3	8	26	3.9	−2.4	1.7	2	24	11	4.0	+2.9	2.6
Royersford 5th, 6th, 7th and 8th grades	M.	78	10	21	47	3.2	−1.7	2.0	10	41	27	2.8	+0.7	1.9
	F.	89	9	22	58	3.7	−1.8	1.8	11	57	21	3.3	+2.3	2.3
Springfield grades	M.	11	0	8	3	4.2	+2.9	2.6	1	10	0	5.9	+5.9	3.2
	F.	13	1	6	6	4.4	+2.2	2.2	1	10	2	5.1	+4.8	3.3
Business men	M.	16	3	5	8	2.2	−0.3	1.4	2	10	4	2.1	+0.9	1.4
Students of Columbia University	M.	40	4	19	17	2.0	+0.2	1.0	3	28	9	2.0	+1.5	1.3
	F.	10	0	6	4	1.8	0.0	1.2	3	7	00	1.8	+1.8	1.1

TABLE IV

THE TWO-CENT POSTAGE STAMP. (*Continued*)

Groups of Subjects	Sex	Total Subjects	Area Cases Correct	Area Cases +	Area Cases −	Area A.E.	Area C.E.	Area A.D.	Ratio Cases Correct	Ratio Cases +	Ratio Cases −	Ratio A.E.	Ratio C.E.	Ratio A.D.	Square
Fulton County teachers	M.	13	0	9	4	129.2	+ 79.7	73.5	1	0	12	13.7	−13.7	07.4	3
	F.	24	0	22	2	164.7	+157.1	93.1	0	2	22	11.8	−11.6	10.8	5
Industrial Institute and College, Miss.	F.	58	0	36	22	90.4	− 34.1	45.8	0	6	52	19.0	−17.0	9.7	15
Jersey City high school	M.	47	0	27	20	92.3	+ 12.1	89.9	0	9	38	13.2	−10.4	8.4	5
	F.	80	1	45	34	113.6	+ 52.8	109.9	0	15	65	16.3	−13.5	10.7	15
Royersford high school	M.	35	0	10	25	97.5	− 54.6	54.2	1	23	11	11.1	− 4.8	10.7	2
	F.	44	2	24	18	98.8	+ 33.2	73.7	2	8	34	17.2	−13.6	12.4	6
Damascus and Springfield high school	M.	26	0	16	10	145.3	+ 15.5	84.3	1	11	14	10.4	− 4.3	6.8	1
	F.	31	0	25	6	155.0	+137.6	105.4	0	1	30	15.7	−15.5	7.5	7
Royersford 7th and 8th grades	M.	26	0	14	12	98.5	+ 00.1	61.5	0	9	17	14.2	− 7.1	7.0	2
	F.	29	0	14	15	104.9	+ 7.0	67.0	0	1	28	22.9	−21.0	7.2	7
Royersford 6th grade	M.	26	0	12	14	74.6	− 25.0	48.4	0	1	25	18.9	−17.0	10.5	4
	F.	23	0	14	9	97.4	+ 21.6	59.1	0	5	18	20.4	−14.6	13.0	5
Royersford 5th grade	M.	26	0	9	17	138.2	− 22.4	70.0	0	0	26	20.0	−20.0	5.9	7
	F.	37	0	20	17	117.1	+ 23.2	72.2	1	0	36	27.2	−27.2	12.3	4
Springfield grades	M.	11	0	9	2	246.9	+231.1	158.8	0	1	10	20.5	−17.8	9.4	2
	F.	13	0	9	4	196.4	+113.6	109.8	1	1	11	21.1	−20.1	9.2	3
Business men	M.	16	3	7	6	75.3	+ 11.6	56.3	0	9	4	7.2	− 7.0	8.7	3
Students of Columbia University	M.	40	1	25	14	99.9	+ 53.0	61.0	1	9	30	10.6	− 7.5	6.0	1
	F.	10	1	7	2	66.0	+ 46.6	48.0	1	0	9	12.5	−12.5	6.7	1

TABLE V

THE TWO-CENT POSTAGE STAMP. (*Continued*)

Groups of Subjects	Sex	Total Subjects	Serrations: Length: Correct	Length: Cases +	Length: Cases −	Length: A.E.	Length: C.E.	Length: A.D.	Serrations: Width: Correct	Width: Cases +	Width: Cases −	Width: A.E.	Width: C.E.	Width: A.D.
Fulton County teachers	M.	10	0	5	5	4.5	−00.7	1.9	0	4	6	5.0	−0.4	1.8
	F.	20	2	3	15	5.2	−00.3	3.7	2	3	15	4.7	+0.7	4.0
Industrial Institute and College, Mississippi	F.	56	9	26	21	4.5	+ 1.7	3.0	1	25	30	3.8	+0.9	2.4
Jersey City high school	M.	42	8	25	9	8.4	+ 7.5	7.9	3	22	17	5.8	+4.3	5.2
	F.	74	8	44	22	7.9	+ 5.8	6.6	6	44	24	5.9	+4.1	4.9
Royersford H. S.	M.	35	6	18	11	7.1	+ 4.9	7.3	4	13	18	5.6	+2.6	5.9
	F.	42	6	24	12	9.6	+ 7.2	8.4	2	24	16	7.4	+4.9	6.4
Damascus and Springfield H. S.	M.	26	5	15	6	5.1	+ 3.6	3.5	1	12	13	3.2	+0.5	2.6
	F.	30	4	20	6	7.3	+ 5.8	5.8	2	16	12	5.5	+3.7	4.7
Royersford 7th and 8th grades	M.	25	2	19	4	14.8	+14.8	9.9	2	14	9	10.5	+8.5	9.5
	F.	29	3	20	6	12.4	+11.0	12.1	0	20	9	8.7	+7.0	7.4
Royersford 6th grade	M.	25	3	14	8	8.5	+ 5.1	7.4	1	11	13	6.6	+3.7	5.5
	F.	20	0	12	8	9.5	+ 5.3	7.6	0	11	9	7.2	+4.4	6.7
Royersford 5th grade	M.	23	2	12	9	10.9	+ 5.9	8.9	2	11	10	9.6	+4.5	5.1
	F.	34	5	21	8	8.1	+ 5.4	6.3	0	25	9	7.7	+5.3	5.1
Springfield grades	M.	8	0	6	2	7.6	+ 4.9	4.3	0	7	1	6.5	+5.0	3.0
	F.	7	0	1	6	4.4	− 3.0	1.7	1	2	4	4.0	−1.7	3.4
Business men	M.	13	1	8	4	6.8	+ 4.9	5.5	1	6	6	5.3	+3.1	4.3
Columbia students	M.	36	2	13	21	3.6	− 0.3	2.4	2	7	27	3.5	−1.2	2.1
	F.	9	1	3	5	3.1	− 0.6	1.2	3	3	3	2.3	−1.2	2.0

TABLE VI

THE TWO-CENT POSTAGE STAMP. (*Continued*)

Serrations

Groups of Subjects	Sex	Total Subjects	Ratio Cases Correct	+	−	A.E.	C.E.	A.D.	No. Square
Fulton County teachers	M.	10	0	4	6	13.6	+ .3	8.0	3
	F.	20	0	6	14	10.4	− 6.4	5.1	8
Industrial Institute and College, Miss.	F.	56	0	40	16	17.8	+ 7.4	11.6	7
Jersey City H. S.	M.	42	2	33	7	20.4	+14.3	11.0	5
	F.	74	0	38	36	18.0	+ 5.1	9.6	18
Royersford H. S.	M.	35	2	26	7	23.9	+18.5	18.3	6
	F.	42	0	26	16	24.1	+11.1	17.0	12
Damascus and Springfield H. S.	M.	26	0	19	7	26.1	+17.7	13.9	5
	F.	30	0	20	10	21.8	+11.0	9.3	6
Royersford 7th and 8th grades	M.	25	0	18	7	35.5	+27.5	25.5	3
	F.	29	0	14	15	23.5	+10.1	15.1	8
Royersford 6th grade	M.	35	0	17	8	21.1	+ 8.3	20.2	3
	F.	20	0	7	13	19.3	+ 2.2	13.7	6
Royersford 5th grade	M.	23	1	10	12	34.9	+19.2	34.6	9
	F.	34	0	15	19	25.0	+ 1.5	28.4	13
Springfield grades	M.	8	0	2	8	20.0	− 6.7	6.7	5
	F.	7	0	2	5	8.7	+ 8.7	1.9	5
Business men	M.	13	0	10	3	21.0	+14.1	12.3	3
Columbia students	M.	36	0	27	9	17.8	+12.8	8.7	5
	F.	9	1	5	3	21.1	+11.1	14.6	3

be expected. However, these results seem to indicate that the ability to estimate magnitudes, such as that of a postage stamp and a one-dollar bill, is determined not so much by the amount of experience with the particular object as it is, perhaps, by certain habits of the subjects. No doubt the boy is more accustomed to estimate dimensions than the girl is, and a girl's experience and esthetic temperament may have characteristics that would suggest a reason for their superiority in estimating the number of serrations.

The "Area" column (Table IV.) shows that among nearly all the groups, the A.E. for the females is much larger than that for the males, and the corresponding C.E.'s indicate that the females draw a longer stamp than the males, while the males draw a larger dollar bill.

With the exception of the country teachers, the A.E. under ratio of the dimensions of the stamp, is uniformly smaller in the case of the males than in the case of the females, while for the ratio for the estimated serrations (Table IV.) per dimension give, with one exception, a reverse tendency. This seems to indicate that the females are more susceptible to the vertical illusion than the males. The females draw the stamp wider than the males but no rule of difference is found for the length (note C.E., Table III.). The C.E. shows no general trend for sex difference in estimating the number of serrations for each dimension (Table V.). Twice as many females as males draw the stamp square (Table IV.)—68 females and 32 males —and about the same ratio obtains for the number of cases that indicate a square stamp by the estimated number of serrations per side—47 males and 86 females (Table VI.).

Curve of Distribution

The central tendency for the high schools in estimating the length of the stamp falls, for the males and females alike, between 0 and —2 millimeters and for the grammar schools between —2 and —4 millimeters. For the females of the rural group it is between 0 and —2 millimeters, and for the males between —2 and —4 millimeters. In all three groups the central tendency for the females is higher than that for the males with no marked sex difference variability from the central tendency.

In estimating the width of the stamp the females of the high schools show a central tendency between 0 and +2 and the males between 0 and —2. The grammar school groups have the same central tendency as the high school but reversed for the sexes; while the central tendency for the rural group is between +2 and +4 millimeters by the females and between 0 and +2 for the males. The

males for the high schools and rural groups give a somewhat flattened curve while the central tendency for the females is very much higher. The central tendency for the males of the grammar schools is the higher. Again there is no marked sex difference in variability. Reference to the tables, however, will show that, in correspondence with the A.E. results, the females vary more from the average than the males.

Results for Coins

The results of the coin test (Tables VII., VIII., IX.) fall into two distinct groups, namely, those for the three smaller coins, cent, nickel, and dime; and those of the three larger coins, quarter, half dollar, and dollar. This division is in consequence of the fact that the coins of the first group are almost universally underestimated, and those of the second group overestimated. This is contrary to the central tendency of judgment indicated by the same subjects in overestimation of the stamp and the underestimation of the bill, as well as to the results of several experiments in memory and judgment for square sizes by Baldwin (86), Hollingworth (96*a*) and others.

It is apparent, therefore, that a standard for judgment prevails in estimating square sizes, different from that maintained in estimating sizes of circles. If the relative values of the coins were the determining factors in the nature of the errors made, one would expect the dime to be estimated larger proportionally than the cent and nickel, but its underestimation is much greater, as the figures show. Baldwin (86) states that "circles tend to be measured by their radii but in the case of the squares the impression is that of area."

The circle assigned to the cent was correctly designated by 174 subjects, 86 males and 88 females. This is such a large number that one can well conclude that it is not a mere chance result but largely a result of correct memory and judgment. One hundred and seventy-two subjects, 82 males and 90 females correctly chose the nickel.

It is a striking fact that for the cent and the nickel the college students make the greatest A.E. (see Figs. 7 and 8). If their estimates were determined purely by experience, it would seem that this group should have less error than the groups representing the lower grades, because a large number of the former group traveled to and from school on five-cent fares. In general, however, there is a rise in accuracy from the lowest to the highest school grades, which fact corroborates the results for the stamp and one-dollar bill. This rise in accuracy with age is scarcely noticeable with the nickel and silver dollar but the curve for these coins maintains an almost level trend (Figs. 8, 4). Perhaps the nickel curve is explained by the fact that

TABLE VII

COINS

Groups of Subjects	Sex	Total Subjects	Cent						Nickel					
			Correct	Cases +	Cases −	A.E.	C.E.	A.D.	Correct	Cases +	Cases −	A.E.	C.E.	A.D.
Fulton County teachers	M.	13	3	7	3	1.2	+ .1	0.8	5	5	3	1.5	+0.3	1.5
	F.	24	4	15	5	1.4	+1.0	1.0	7	13	4	1.4	+ .7	1.2
Industrial Institute and College, Mississippi	F.	58	11	5	42	1.8	−1.5	1.2	12	9	36	1.5	−1.1	1.0
Jersey City H. S.	M.	47	18	12	17	.8	.0	.6	18	14	15	1.0	+ .1	.8
	F.	82	24	27	31	1.0	.0	.6	18	34	30	1.3	+ .2	.8
Royersford H. S.	M.	35	9	2	24	1.6	−1.4	1.1	9	5	21	1.3	− .8	.9
	F.	44	5	12	27	1.6	−1.0	1.0	10	11	23	1.7	−1.0	1.3
Damascus H. S.	M.	17	5	4	8	1.7	−1.2	1.4	5	5	7	1.4	− .6	1.1
	F.	16	4	6	6	.9	+ .1	.6	6	5	5	.7	+ .1	.9
Springfield H. S.	M.	9	2	5	2	.9	+ .2	.4	3	4	2	.9	+ .2	1.0
	F.	15	5	3	7	1.3	− .4	1.0	5	6	4	1.5	+ .4	1.1
All high schools	M.	108	34	23	51	1.2	− .6	.9	35	28	45	1.2	− .3	.9
	F.	157	38	48	71	1.2	− .3	1.2	39	56	62	1.2	− .1	.9
Royersford 7th and 8th grades	M.	25	6	1	18	1.9	−1.8	1.3	5	3	17	2.0	−1.4	1.3
	F.	29	6	7	16	1.4	− .7	1.0	7	7	15	1.1	− .6	1.0
Royersford 6th grade	M.	24	9	2	13	1.4	−1.2	1.2	5	4	15	1.4	− .9	1.0
	F.	22	6	6	10	1.8	− .8	1.4	3	5	14	1.5	−1.5	.8
Royersford 5th grade	M.	23	2	2	19	2.6	−2.5	1.5	1	4	18	2.4	−1.7	2.9
	F.	36	11	2	23	1.8	−1.7	1.5	6	10	20	1.7	− .8	1.2
Springfield grades	M.	8	1	3	4	2.2	− .1	.7	1	3	4	1.5	.0	.7
	F.	13	6	6	1	2.1	− .5	1.2	13	6	7	2.3	− .1	1.1
Bankers	M.	29	11	6	12	.9	− .3	1.9	10	6	13	1.1	− .6	.6
Business men and women	M.	56	15	11	30	1.3	− .8	.9	13	16	27	1.4	− .9	1.0
	F.	12	5	2	5	1.0	− .5	.8	1	4	7	1.0	− .3	.2
Columbia stu. coins chosen	M.	36	5	8	23	3.5	+ .7	2.0	7	11	18	1.9	− .6	1.2
	F.	11	1	3	7	2.3	−1.1	1.3	2	5	4	2.5	0	1.5
Columbia stu. coins drawn	M.	33	5	13	15	1.7	− .4	1.2	6	11	15	1.7	− .4	1.2
	F.	11	0	6	5	2.3	− .4	1.6	3	5	3	2.3	− .3	1.9

TABLE VIII

COINS. (*Continued*)

Group of Subjects	Sex	Total Subjects	Dime						Quarter						Total Subjects
			Correct	Cases +	Cases −	A.E.	C.E.	A.D.	Correct	Cases +	Cases −	A.E.	C.E.	A.D.	
Fulton County teachers	M.	13	2	4	7	1.4	− .8	.9	2	6	5	2.7	+1.8	2.2	13
	F.	24	4	9	11	1.2	− .2	.6	7	13	4	2.7	+2.2	2.3	24
Industrial Institute and College, Mississippi	F.	58	5	3	50	2.8	−2.6	1.2	9	6	43	1.6	−1.2	1.0	58
Jersey City H. S.	M.	45	6	10	29	1.7	−1.1	1.2	13	21	13	1.6	+1.0	1.2	47
	F.	82	17	8	57	1.9	−1.3	1.3	15	48	19	2.2	+1.6	1.6	82
Royersford H. S.	M.	35	1	2	32	2.8	−2.4	1.3	6	12	17	2.0	0.0	1.4	35
	F.	44	4	3	37	2.8	−2.6	1.5	11	18	14	1.9	+3.0	1.5	43
Damascus H. S.	M.	17	0	5	12	2.3	−1.3	1.1	2	10	5	2.2	+1.2	1.2	17
	F.	16	1	2	13	1.5	−1.1	.7	2	2	12	3.0	+2.7	2.1	16
Springfield H. S.	M.	9	2	1	6	1.4	−1.2	1.0	0	7	2	2.7	+2.2	1.9	9
	F.	15	4	1	10	1.9	−1.4	1.3	3	11	1	2.6	+2.3	1.9	15
All high schools	M.	107	13	14	80	2.0	−1.6	1.5	21	50	37	2.0	+ .9	1.4	108
	F.	157	26	14	117	2.1	−1.7	1.3	31	90	35	2.4	+1.2	1.7	156
Royersford 7th and 8th grades	M.	25	0	1	24	3.6	−2.8	1.3	3	7	14	1.8	− .3	1.1	24
	F.	29	3	2	24	2.4	−2.2	1.5	5	12	12	2.1	+0.5	1.6	29
Royersford 6th grade	M.	24	1	0	23	2.9	−2.9	1.2	6	7	11	1.4	− .1	1.1	24
	F.	22	0	2	20	2.8	−2.6	.9	2	9	10	2.6	+1.1	1.7	21
Royersford 5th grade	M.	23	1	2	20	3.7	−3.2	1.3	1	7	14	2.1	0.0	1.3	22
	F.	35	1	3	31	3.0	−2.8	1.3	2	18	16	3.3	+1.9	2.3	36
Springfield grades	M.	8	0	0	8	3.7	−3.7	2.0	1	6	1	4.1	+3.9	2.9	8
	F.	13	0	3	10	2.8	−1.8	0.9	1	9	3	5.1	−3.9	1.9	13
Bankers	M.	29	7	3	19	1.7	−1.5	1.3	10	12	7	.8	+0.3	0.7	29
Business men and women	M.	56	13	6	37	1.5	−1.2	0.7	6	26	24	1.4	+0.1	0.8	56
	F.	12	3	0	9	1.7	−1.7	1.2	2	8	2	1.7	+1.2	1.2	12
Columbia stu. coins chosen	M.	34	2	7	25	2.5	−1.7	1.4	8	19	9	2.5	+1.1	1.2	36
	F.	11	0	2	9	2.5	−2.2	1.5	1	6	4	2.8	+1.2	1.4	11
Columbia stu. coins drawn	M.	32	7	6	19	1.8	−0.7	1.4	8	5	9	1.7	+1.0	1.3	32
	F.	11	1	3	7	2.9	−0.9	1.9	0	10	1	3.7	+3.0	1.7	11

TABLE IX

COINS. (*Continued*)

Groups of Subjects	Sex	Half Dollar							Silver Dollar						
		Total Subjects	Correct	Cases +	Cases −	A.E	C.E.	A.D.	Total Subjects	Correct	Cases +	Cases −	A E	C.E.	A.D.
Fulton County teachers	M.	13	0	8	5	3.9	+2.7	2.2	13	0	9	4	3.9	+3.0	6.0
	F.	23	3	17	3	3.4	+2.2	1.9	24	0	19	5	3.5	+2.4	1.7
Industrial Institute and College, Mississippi	F.	58	7	24	27	2.4	−1.4	1.4	54	5	20	29	2.6	0.0	1.5
Jersey City H. S.	M.	45	7	29	9	2.5	+1.7	1.1	46	1	32	13	3.0	+2.0	1.6
	F.	82	4	59	19	3.3	+2.3	1.9	82	8	46	28	3.1	+1.4	1.5
Royersford H. S.	M.	35	4	22	9	2.9	+0.9	1.8	35	3	26	6	3.6	+2.5	1.7
	F.	43	3	34	6	3.6	+2.6	2.5	43	5	28	10	3.1	+1.8	1.6
Damascus H. S.	M.	17	2	12	3	2.3	+1.9	1.1	17	1	13	3	3.4	+2.5	1.5
	F.	16	0	15	1	3.7	+3.3	2.2	16	1	12	3	3.2	+2.6	1.5
Springfield H. S.	M.	9	0	8	1	3.4	+2.5	1.4	9	0	6	3	4.1	+2.3	1.7
	F.	15	0	12	3	3.6	+2.7	1.6	14	0	7	7	3.3	+1.0	2.0
All high schools	M.	106	13	71	22	2.6	+1.4	1.5	107	12	82	13	3.3	+2.2	1.6
	F.	156	7	120	29	3.4	+2.5	2.1	156	14	94	48	3.1	+1.5	1.6
Royersford 7th and 8th grades	M.	25	2	16	7	3.9	+2.2	1.9	25	2	18	5	4.3	+3.2	1.9
	F.	29	2	22	5	3.7	+2.8	2.4	27	3	18	6	3.2	+2.1	1.8
Royersford 6th grade	M.	24	2	18	4	2.9	+1.7	1.5	24	0	21	3	4.1	+3.3	1.7
	F.	21	0	18	3	3.1	+2.2	1.7	21	4	14	3	3.2	+2.7	2.2
Royersford 5th grade	M.	23	0	21	2	3.2	+2.3	2.1	23	3	17	3	3.8	+3.4	2.1
	F.	36	1	31	4	4.0	+3.4	1.0	36	1	33	2	4.6	+4.1	1.7
Springfield grades	M.	8	1	6	1	2.9	+2.4	1.6	8	2	4	2	3.1	+1.9	2.0
	F.	13	0	10	3	5.7	+4.0	2.6	12	0	11	1	4.6	+3.0	2.0
Bankers	M.	29	2	20	7	2.0	+1.2	1.1	29	2	20	7	3.1	+2.1	0.5
Business men and women	M.	56	7	42	7	2.3	+1.6	1.2	56	7	42	7	3.5	+3.1	1.8
	F.	12	1	10	1	3.4	+3.1	2.1	12	0	12	0	4.7	+4.7	1.0
Columbia stu. coins chosen	M.	36	2	29	5	3.0	+2.1	1.5	36	6	19	11	3.3	+0.9	2.0
	F.	11	1	8	2	3.6	+2.5	1.8	10	1	6	3	3.7	+1.9	1.3
Columbia stu. coins drawn	M.	32	4	8	20	3.0	+1.8	2.1	32	3	7	22	4.7	+3.2	3.3
	F.	11	0	2	9	3.5	+2.2	1.8	11	1	2	8	5.8	+4.3	3.0

practically all children are equally well acquainted with the nickel. However, for the same reason one would expect the curve for the cent to correspond with that for the nickel, but it does not (see Fig. 7). One might presume, since the cent was chosen first, that the nickel, which all estimated as larger than the cent, was estimated much larger proportionally, *i. e.*, relative differences were exaggerated. The figures seem to correspond to this hypothesis, but introspections did not bear it out, and it can hardly account for the two distinct groups of coins underestimated and coins overestimated, unless it be maintained that the large difference between the size of the dime and the quarter induced the calling forth of a new standard for the larger coins.

About one half of the subjects were asked to choose and draw the coins in reverse order to the relative values and no differences in relative sizes could be found. In this case the subjects, as a rule, after drawing or choosing in reverse order checked up their drawings by a judgment in the opposite direction. The writer is not sure what might have been the results had the subjects been made to choose the coins in a varied order. Even then the process of comparison in order of values could not have been eliminated. The greater suggestibility of the lower grades may account for the choice of proportionally smaller circles for the silver dollar by them.

For the cent and nickel the lowest C.E. and A.D. is found with the Jersey City high school, but the lowest average error for the cent is by the bankers and by the male country teachers. All measurements for the merchant group are correspondingly low.

Figs. 3, 5, and 6 show the curve of the A.E. for the remaining coins. It will be observed that while the A.E. for the nickel and cent are practically the same, the A.E. for the other coins increase in order of their values, and the C.E. and A.E., correspondingly. The C.E. (Table VIII.) does not show a single positive C.E. group for the dime while there are but few negative cases for the quarter. In Table IX. the college student group does not stand so high in A.E.

The writer can find no reason why the Industrial Institute and college girls do not follow the general rule with the larger coins, instead they have a negative C.E. Their results rather weaken the "exaggerated difference" hypothesis offered above. Difference in experience may be a determining factor.

Sex Difference

The following statement represents the per cent. of correct cases for the coins. The subjects are combined without regard to age and training.

	Men (322)	Women (362)
Cent	26.7	24.3
Nickel	25.5	24.9
Dime	17.8	11.7
Quarter	18.1	16.7
Half-dollar	9.1	6.1
Silver Dollar	8.4	7.9

Even when the bankers are excluded in determining the averages the males excel for all coins. The curves, figures and tables show that for the smaller coins the females make fewer errors than the males but more errors for the larger coins than the males, with few exceptions. The C.E. and A.D. correspond in general to the A.E. as in the case of the stamp and bills. Therefore the females tend to underestimate the smaller coins less and to overestimate the larger coins more than the males.

In drawing the coins the males show a decided superiority over their choosing of circles for all coins, except the dollar. This superiority was consistent for individual cases as well as for the group. The women gave a poorer record for the dime, quarter and dollar, in their drawings than in their choosing of circles (see group, Tables VIII. and IX.). For all coins, in all the columns, the women appear inferior to the men in drawing the coins, and with the exception of the dime the women drew the coins larger than did the men. However, only 12 women were tested in this way.

The curve of distribution for the nickel which represents the smaller coins, shows a central tendency for the high schools, grammar grades and rural groups of both sexes to be between 0 and +1 millimeter. For all these groups the central tendency is higher for the males than for the females, but the extremes in variability show little or no sex difference. For the quarter which represents the larger coins, the central tendency for both sexes of the grammar school group falls between 0 and —1 millimeter, and the same is true for the boys of the high schools and the girls of the rural group; but the girls of the high schools and the boys of the rural group have a central tendency between 0 and +1. Again the central tendency for the boys is considerably higher than that for the girls and the extremes of variability are about the same for both sexes.

The table of frequency (not provided here) for the silver dollar shows a skewed curve with a rapid dropping off on the plus side of the central tendency. This exception to the normal curve is more pronounced for the males than for the females, because more females than males seemed to be open to suggestion, and fewer chose the larger circle (No. 35); while more men chose No. 35. A few men

stated that no circle on the cardboard was large enough. Consequently the females seem to be better than males in estimating the size of the silver dollar.

Corrections for the One-dollar Bill

It was found that of the 326 male subjects 61 or 18.7 per cent. corrected for the one-dollar bill so as to make it longer than the original drawing, with an average of 13.5 mm., and 60 or 18.4 per cent. wider, with an average of 6.3 mm. Of the 354 females, 68, or 19.2 per cent. increased the original length by an average 12.7 mm., and 69 or 19.5 per cent. increased the width by 7 mm. (see Table X.). Only one subject corrected the length shorter and three the width. All who corrected for length corrected in the right direction, and all

TABLE X

PER CENT. OF CASES MAKING CORRECTIONS FOR DRAWING OF THE ONE-DOLLAR BILL

	Males		Females	
	Length	Width	Length	Width
Columbia University	20.93	18.60	33.33	41.66
All high schools	22.02	19.26	25.95	20.25
All grammar schools	11.53	10.25	5.62	12.35
Fulton Co. teachers	8.33	8.33	20.80	16.66
Merchants	30.36	35.71	15.39	7.69
Bankers	3.57	7.14		
Indus. Inst. and Col.			18.96	27.58
Total	18.71	18.41	19.21	19.48
Average increase in millimeters	13.53	6.27	12.68	6.96

but 7 who corrected for width did likewise. Twenty-two males and 30 females increased both the length and the width at the same time. For both sexes there is a far greater number of cases among the high school who made corrections, than among the grades. The above figures show that the females, on the average, increased the width more, and the length less than the males; the ratio of the increase of the width to that of the length is, for the males 2.15, and for the females 1.82. Twice as many of the female country teachers as the male ones made corrections. Few corrections were made by the bankers.

The Five-dollar Bill

This test was made chiefly to study the influence of suggestion (67, 68, 70). Table XI. shows for the five-dollar bill merely the per cent. of cases that estimated the five-dollar bill shorter than the one-dollar bill (per cent. + cases) and those longer than the one-dollar bill (per cent. — cases). The average and the constant variation from the dimension of the dollar bill were estimated for each. There

are more cases of those who estimate the five-dollar bill smaller than the one-dollar bill than one might expect to find. While the regular size for each bill is the same there is a $5.00 national bank note which is shorter and wider than the one-dollar bill. But such are comparatively few in number. A few of the minus cases may be due to

TABLE XI

THE FIVE-DOLLAR BILL

R. and J. C. H. S.

	Length				Width			
	Per Cent. of +Cases	Per Cent. of −Cases	A.D. Mm.	C.E. Mm.	+Cases	−Cases	A.D. Mm.	C.E. Mm.
Males.....	19.3	8.4	2.61	+1.02	13.3	13.3	1.53	−0.01
Females....	21.3	5.5	2.87	+1.59	18.1	6.3	1.45	+0.81
Seventh and Eighth Grades								
Males.....	30.8	0.0	2.50	+2.50	23.1	7.8	1.96	+1.58
Females....	24.1	13.8	1.83	+0.93	24.1	13.8	3.34	+1.21
Fifth and Sixth Grades								
Males.....	73.1	11.5	11.11	+8.62	55.77	21.2	5.19	+3.46
Females....	63.3	6.7	9.73	+9.13	43.3	28.3	4.36	+2.10
I. I. and C.								
Females....	22.4	8.6	3.13	+2.00	27.60	5.2	1.64	+1.53
Total								
Males.....	38.5	8.1	5.28	+3.66	28.6	14.9	2.78	+1.38
Females....	30.0	7.3	4.32	+3.26	26.3	11.7	2.33	+1.31

chance, as there are some cases where the difference is very noticeable. In all cases the two bills were drawn on the same page. Many of the individual subjects said upon being asked to draw the five-dollar bill, "They are the same, aren't they?" and when no reply was given they drew the five-dollar bill smaller or larger. Upon being questioned these subjects would answer, "I thought there must be some difference else you would not have asked me to draw both." Some reasoned: "A ten-cent piece is smaller than a five-cent piece, so I guess a five-dollar bill is smaller than a one-dollar bill."

The rather large number of plus cases can not be wholly due to suggestibility, in view of the fact that all those who corrected the one-dollar bill increased its size, and since the five-dollar bill was always drawn after the one-dollar bill. The table shows for the men an average C.E. from the length of the one-dollar bill, of +3.66 millimeters and from the width, +1.38; for women, +3.26 and +1.31 respectively. On the average, more subjects of the grades lower than the high school assigned a larger size to the five-dollar bill than to the one-dollar bill, thus indicating that suggestibility de-

creased as age increased. For the length the figures are: 20 for the high school, 27 for the 7th and 8th grades, and 65 for the 5th and 6th grades, respectively, out of a hundred (see table). The same tendency obtains for the width.

Introspective Observations

Few subjects manifested confidence in their results before checking them up, and some insisted that they "had not the least idea" of the size of the bill and stamp. Sometimes great surprise was indicated by the subject in exclamations varying from an "Oh!" to profanity, when he discovered the magnitude of his error. Introspections showed that very few subjects estimated the dimensions in terms of inches or centimeters; instead, they said to themselves, "It looks so long" or "so wide." Some used special devices for calling up the sizes to be represented. One said that he measured the size of a dollar bill by the space it would cover in the palm of the hand. Some said they thought of their purse and drew the bill accordingly. A merchant called to mind his bank book, and various other devices were reported by other subjects.

A few subjects marked the serrations on the stamp first and then counted them, saying that they determined the number by the way they "looked."

In drawing the coins the subjects seemed to draw each coin in relation to the first one drawn. Sometimes a subject after drawing the last coin, namely, the silver dollar, would start over again on a new basis saying, "All these are wrong."

Conclusion

The results show that the size of the one-dollar bill is almost universally underestimated; the underestimation of the length is much greater than that of the width. The area of the stamp is, as a rule, slightly overestimated, the length is underestimated and the width greatly overestimated. The three smaller coins are underestimated and the three larger ones are overestimated. The amount of overestimation and underestimation of the sizes of the one-dollar bill, stamp and coins decreases as age and experience increases, and is, as a rule, greater for the females than for the males. Generally the males are better performers than the females and less variable. There is a tendency to estimate the five-dollar bill larger than the one-dollar bill. Those who corrected their first drawings for the one-dollar bill made them larger, and consequently more nearly correct.

CHAPTER III

Incidental Memory for Words

In the previous experiments, there was no definite way of determining the frequency and duration of the stimuli. The following test is an attempt to more nearly standardize the material and the time of exposure. Some method was desired wherein the thing to be remembered would be merely incidental and where the focus of the subject's interest would be directed strongly away from the facts to be called for after the exposure of the stimuli. On the other hand, it was desired that these things, to be called for, should wholly, or in part at least, come into the subject's experience. To this end a list of six words was used. The subject was told that he would be given a spelling test, and he was led to believe that it was a real test of speed and accuracy in spelling. He was provided with a piece of paper, which he was told to use in a little practise with figures, in order to show the manner in which the words would be given.

Presenting a piece of paper with columns of figures on it, the experimenter showed how they should be written when they were pronounced. "When I give the signal to begin," he said, "write the figures as rapidly as I give them, and at the signal 'turn,' grasp the paper with the hand unused in writing, and turn the page so that the bottom of the sheet becomes the top when turned" (the experimenter demonstrating). This precaution was taken to avoid the aid of the pencil impressions that might be visible through the paper. The figures were pronounced rapidly so that the subject could scarcely keep pace. The practise was given three times, and after each practise the experimenter insisted that the paper was not turned quickly enough, and that unless the subject turned the paper quickly he would lose out in the word-test which was to follow. When the third practise was ended, the subject was told that the words would not be pronounced quite as fast as the figures had been pronounced, but that no time should be lost in turning the page. Following the signal "ready," the words were given in the following order: pickle, angel, dirt, busy, onion, women, with a speed such that each word was pronounced just as the subject was completing the previous word. After the signal "turn," the directions were: "Write as many of these words as you can remember, arranging them in the

order I gave them.''[1] At this command the stop watch was set going and the subject was given as much time as he desired to reproduce the words. When he had finished the task, or had given up, the watch was stopped. He was then told to indicate by a dash each word omitted, and to state the number of words that he thought were given in the test. Introspections were obtained, and the facial expressions and emotional attitudes of the subject during the performance were noted. When 32 subjects had been tested, the order of the first two words of the stimuli was interchanged as the writer had learned from the introspections of a few subjects, that there was a tendency to combine them, making the first word modify the second, as ''pickled angel,'' thus aiding in recall. This second order was maintained throughout save in a few cases, where an attempt was made to study order effect.

As in the stamp and money tests, this experiment was made on about 75 individual subjects before it was applied to a group. It was feared that with groups such as public school children the experiment could not well be controlled; but experience proved that the difficulty was not great, and that by means of the drill test the papers were turned with practically a uniform quickness, thus avoiding a backward glance over the list of words.

In order that conditions might be rendered as nearly normal as possible, the experimenter spent some time getting acquainted with the pupils before making the tests. He especially tried to make the young children feel at ease. The groups were assured by their respective teachers that the test was not an examination, yet at the same time they were urged to follow accurately the instructions that would be given. After indicating their names, age, sex and grade, they were given full explanation, and a demonstration was made showing how they should proceed. They were told that no question would be answered after the test began and that no one must speak or whisper during the experiment. This precaution was stated a second time. Practically the same methods were pursued as in the individual test. More emphasis was placed, however, on the directions, ''Indicate by a line the words omitted,'' and the time was limited to one and one half minutes. The experimenter repeated at the respective intervals ''one half minute, one minute, fold paper quickly.'' This was not done in the individual tests. In case of the immediate response, no attempt was made to get an estimate of the number of words. With most of the groups, however, the reproduc-

[1] The method of reconstruction was first used by Münsterberg and Bigham (87*b*), with colors; later by Smith (105) in the ''letter square'' test, and by Miss Gamble (95) with odors.

tion was made at various intervals after the presentation of the stimuli, ranging from one half hour to three months. In these cases a practise drill in rapid folding of papers was added to the above planned procedure. The subjects were assured that no papers would be received in case the paper was not quickly folded at the signal. In all cases the last word was pronounced with the voice raised, as if another word were to follow; but instead, the experimenter said, "Fold paper quickly." The papers were collected and the experimenter, without further comment or remark, left the room to return again unexpectedly at the various intervals selected. The teachers were always informed as to the purpose and manner of the test, and they heartily cooperated by allowing the writer to interrupt their school work promptly at the desired interval, which was often in the midst of a recitation.

Upon the experimenter's reappearance, the subjects were again provided with paper and asked to label it as they had done before. Then the writer said, "You will remember that I was here before, and that you were so kind as to spell some words for me. You thought I was going to give you something hard, but you know that I did not. Now I am going to ask you to do some more work for me. Just as before, I want you to fold the papers quickly when I tell you. You will have a minute and a half in which to do this work. That is a good while. If, however, you finish the work in less than one and one half minutes, and many of you will, please fold your papers that no one else may see your work. Do not begin till I say, go." These directions were slowly and emphatically repeated, and it was especially emphasized that no one begin before the signal "go."

"Now you will remember that I asked you to spell some words when I was here before. No one begin until I say, 'go.' Write as many of these words as you can remember, arranging them in the order I give them, first one first, second one second, etc.—Go." Then after the regular instructions and procedure the experimenter said, "Fold papers quickly. Do not open the papers until I tell you. Do not whisper or repeat the answer to the next question aloud, but when I tell you to open the paper you will quickly unfold it and write in a large figure or figures, showing how many words you think I gave you the other time. Then fold again quickly." In view of the earlier practise, uniform response was easily secured. The papers were then collected and the subjects were assured that this was the last test. Before he left the room, the writer stated in a casual way the number of words and pronounced them in their order. Careful watch was made by the writer and the teachers. The period of time

given was so brief and the attention necessarily so fixed by the novelty of the test, that little opportunity was afforded to cheat.

After three months the writer returned again to one school (Royersford) and proceeded in exactly the same way as in securing the first recall, to get from the children a reproduction without the words being repeated by the experimenter. They were requested to underscore all words about which they were absolutely sure.

There were 1,663 subjects—773 males and 890 females. The individual subjects consisted of 64 men (one half graduate students) and 12 graduate women students of Columbia University; and 52 male students of Ursinus College. These subjects performed this test along with several other experiments which will be described later. Hearty cooperation was secured, because all the Ursinus group were known personally by the experimenter and most of the college subjects were students in psychology. Five series of groups were tested. The first series reproducing immediately after the presentation of the stimuli, the second one half hour afterwards, the third three and one half hours afterwards, the fourth four and one half hours, and the fifth, six hours afterwards.

Immediate

Collegeville Schools

High school, 31 ..... Males 14, females 17
Fifth and sixth grades, 19 ..... Males 8, females 11

Waynesboro Schools

Seventh and eighth grades, 40 ..... Males 21, females 19
Fifth and sixth grades, 33 ..... Males 12, females 21

Fulton County Teachers

Rural teachers, 77 ..... Males 31, females 46

Shippensburg Normal School

Seniors, 20 ..... Males 20, females 0
Model School—5th to 8th grades, 44 ..... Males 17, females 27

In all these groups the conditions were favorable for the experiment.

After One Half Hour

Royersford Schools

High school, 91 ..... Males 42, females 49
(Seniors, 18 ..... Males 8, females 10
Juniors, 20 ..... Males 6, females 14
Sophomores, 32 . Males 19, females 13
Freshmen, 21 ... Males 9, females 12)
Eighth grade, 33 ..... Males 16, females 17
Seventh grade, 40 ..... Males 19, females 21
Sixth grade, 33 ..... Males 12, females 21
Fifth grade, 36 ..... Males 17, females 19
Fourth grade, 26 ..... Males 15, females 11

As referred to before, the conditions in these schools were as nearly ideal for such an experiment as one could hope to have them. With the exception of the high school they were tested by single grades. All groups were tested on the same half day. There was no intermission between the presentation of the stimuli and the response, and as in all the tests for delayed recall, the regular school work was resumed after the test had been made.

After Three and One Half Hours

Boyerstown Schools

High school, 96 ..... Males 52, females 44
Seventh and eighth grades, 74 ..... Males 39, females 35
Fifth and sixth grades, 76 ..... Males 28, females 48

The records from this school are considered by the writer to be reliable.

After Four and One Half Hours

Chambersburg Grades

Eighth grade, 73 ..... Males 39, females 34
Seventh grade, 78 ..... Males 31, females 47
Sixth grade, 43 ..... Males 0, females 43
Fifth grade, 76 ..... Males 30, females 46
Third and fourth grades, 74 ..... Males 31, females 43

After Six Hours

Chambersburg High School

All classes, 204 ..... Males 84, females 120

The different periods for delayed recall in the Chambersburg schools were set to accommodate the school system. Special advantages prevailed, however, in the cooperation of the high school principal who was once the writer's teacher. The general discipline and seating conditions of the high school and part of the grades were very favorable, but a few of the lower grades were somewhat crowded, so as not to give perfectly ideal conditions for the experiment.

After Seven Days

Westchester State Normal School

All classes, 64 ..... Males 6, females 58

This test was made by the professor of education and psychology. All other groups were tested by the writer.

Objections might be raised to the tests of the groups after three and one half, four and one half hours and six hours and seven days intervals because the subjects in these cases had an opportunity at

the noon recess period to talk over the words and those who went home might have discussed the spelling test, thereby calling up the words; but the teachers observed no evidences of exchange of notes by the pupils who remained in the school building. It might be noted, however, that no test in memory can be wholly reliable, where the subjects have free communication between the time of the presentation of the stimuli and that of the response. For this reason greater emphasis will be placed on the results of the Royersford schools than those of the other "delayed recall" groups. The reader may be confused by the disparate varieties of groups, but he will understand it when consideration is made that subjects are not always easily accessible, and that the results can not be of any value where the purpose is at all suspected.

A test with the same stimuli was made on 24 boys and 22 girls of the 5th and 6th grades, with a view of determining the results when the subjects fully knew they would be expected to give reproductions later. Of course, objections could be raised to the small number of words used because there is no way of evaluating the records of the large number who made perfect reproductions. It was not discovered until later in the course of the experiments with words that the words used as stimuli were a little too difficult for the 3d and 4th grades, and as a result the records for these grades are not wholly comparable with those of the higher grades.

As a check on this difficulty, a test consisting of letters and digits was made in the following order: m, 5, y, r, 8, w, k, 6, p. This was given after the manner of the word test, but words instead of figures were used in the practise drill. Results were obtained only for immediate response. From introspection it was learned that occasional subjects suspected the purpose of the test, but in the word test the real purpose was very easily concealed from the subject.

The "character-test" was first made on a group of 25 college subjects—14 men and 11 women. With them only 9 characters were used, but as it was found that a number had reproduced all the characters, one more was added, namely, "p." The corrected test was made on 83 school children distributed as follows:

Fifth and sixth grades, 24	Males 8, females 16
Third and fourth grades, 32	Males 12, females 20
Second grade, 27	Males 15, females 12

As in the word test, the writer was the experimenter, except with the second grade, where the teacher made the test under the personal

direction of the writer. Following the reproduction in the first experiment, a second test was given in like manner, the subject, of course, knowing the whole plan of the test. The object was to compare incidental with "attentive" memory. However, little space will be given to the second test, as the results show a decided interference as indicated by the large number of characters of the first series. Furthermore, there is no assurance that the two series were of equal difficulty. If two equally difficult series were determined upon empirically, and a sufficiently long interval of time were maintained, such a test could be so applied as to contribute much valuable information.

Results

The number of subjects indicated in the above named groups include only those whose papers showed that they received all the stimuli matter in the presentation. Only about a score in all had to be discarded. The results were tabulated in the order given by the subjects. The number of words omitted was determined for each subject, and tables of frequency and general averages were obtained for each group. Then the groups were considered as to the frequency with which each word appeared both in and out of order. The average per cent. of correct words reproduced was computed. The per cent. in order of the whole number of words given as stimuli, and the per cent. in order of the whole number of words in reproduction were likewise obtained.

According to Spearman's Foot-Rule, given by Whipple in his "Manual of Mental and Physical Tests," page 367,

$$R = 1 - \frac{\Sigma d}{\frac{(n^2 - 1)}{3}},$$

a correlation was estimated between the true presentation as to order and content, with the reproduction of each individual, *i. e.*, an index of efficiency.[2] Whipple has so clearly described this test that space here need not be given. Suffice it to say that the computation for each individual's efficiency was rendered more humane than would appear at first reading the formula, by means of a table which the writer derived from this rule. This table is given below.

[2] In the formula, R is the coefficient of correlation, n the number of cases, and d the difference between the given and the reproduced position of each word in the list.

TABLE XII

Σd	None Omitted	One Omitted	Two Omitted	Three Omitted	Four Omitted	Five Omitted
1 =	.91	.75	.58	.41	.25	.08
2 =	.83	.66	.50	.33	.16	—.003
3 =	.74	.58	.41	.24	.08	—.09
4 =	.66	.49	.32	.16	—.003	—.17
5 =	.57	.41	.24	.07	—.09	—.26
6 =	.49	.32	.15	—.01	—.17	—.35
7 =	.40	.23	.07	—.10	—.26	—.43
8 =	.31	.15	—.01	—.18	—.35	—.52
9 =	.23	.07	—.10	—.27	—.43	—.60
10 =	.14	—.02	—.18	—.35	—.52	—.69
11 =	.06	—.11	—.27	—.44	—.60	—.77
12 =	—.03	—.19	—.35	—.53	—.69	—.86
13 =	—.11	—.28	—.44	—.61	—.77	—.95
14 =	—.20	—.36	—.53	—.70	—.86	
15 =	—.29	—.45	—.61	—.78	—.95	
16 =	—.37	—.53	—.70	—.87		
17 =	—.46					
18 =	—.54					

Σd = sum of deviations or differences in position in the list of words.

One d with one word omitted gave .75 efficiency; one d and three omitted, .41; etc.

These correlations were reduced from "*R*" to "*r*," according to Spearman's table given in Whipple's "Manual," p. 36.

Table XIII. gives the tables of frequency for the general efficiency, but in rather large groupings. In computing the average efficiency, however, only equal records were grouped together. Some minus cases are noted which mean that there were some subjects whose records were lower than a mere chance performance. A comparison between the group record and those of the individual subjects is not wholly fair because there is some probability that a few of the group-cases were scored too low by the method, because there might have been some where the position of the omitted words was not indicated in spite of the fact that the directions to draw a dash or omit a line for each omitted word was emphasized.

After one half hour not a single case made a perfect record, while in the group of 203 subjects tested after six hours interval, 7 made perfect records. Out of 1,191 cases—554 females and 637 males—only 47—29 females and 18 males—had perfect records, *i. e.*, about one female out of 20 and one male out of 35 recalled the six words in correct order. The distribution of cases of 100 per cent. efficiency was as follows:

Immediate Recall

		100 Per Cent. Efficiency		100 Per Cent. Efficiency
University and college	Males 116,	5,		
Fulton County teachers	Males 31,	0,	females 47,	4
S. model school	Males 17,	3,	females 27,	6
One Half Hour Later				
Royersford high school	Males 42,	0,	females 49,	0
Royersford 5th, 6th, 7th, 8th grades	Males 64,	0,	females 78,	0
Boyerstown High School				
Boyerstown high school	Males 52,	0,	females 44,	1
Boyerstown 5th, 6th, 7th, 8th grades	Males 87,	3,	females 63,	3
Four and One Half Hours Later				
Chambersburg 5th, 6th, 7th, 8th grades	Males 143,	6,	females 127,	9
Six Hours Later				
Chambersburg high school	Males 84,	1,	females 119,	6
Total (1,191)	Males 637,	18,	females 554,	29

According to the table (XIV.) of frequency for the number of words recalled without regard to order, the central tendency for immediate recall is at 5 for the college group, and for the grades it is at 6. The girls vary less from the central tendency than the boys. The male teachers have a central tendency at 4, and the females at 5; but for the grades the central tendency is the same for each sex. There is a higher central tendency for the groups tested after the interval of three and one half hours, four and one half hours, and six hours respectively, than for the groups tested after one half hour interval.

For immediate recall no subject reproduced less than two words. Two boys after one half hour, one girl and one boy after three and one half hours, two boys after four and one half hours, were not able to recall any of the words; but after an interval of six hours all were able to reproduce some words.

The variability from the central tendency decreases, as a rule, with the increase of age. The boys in the high schools and the country teachers are more variable than the girls. The reverse is true in the grammar grades. Some of the Chambersburg group can not be considered as before noted. In the letter test the females are more variable than the males.

In Table XV. the average per cent's. for correct words reproduced and the average of efficiency for the various groups are given. The groups that reproduced immediately after the stimuli were presented show high averages. Seventy-five per cent. was the lowest given for words. The group that was told the purpose of the test

TABLE XIII

Frequency Table for Efficiency

Per Cent.	Immediate					One Half Hour Afterward				Three and One Half Hours Afterward				Four and One Half Hours Afterward		Six Hours Afterward	
	Columbia University (116) Males	Fulton County Teachers		Shippensburg Model School		Royersford				Boyertown				Chambersburg			
		High School				High School		Grammar School		High School		Grammar School		Grammar School		High School	
		Males (31)	Females (47)	Males (17)	Females (27)	Males (42)	Females (49)	Males (64)	Females (78)	Males (52)	Females (44)	Males (87)	Females (63)	Males (143)	Females (127)	Males (87)	Females (119)
100–90	18	3	7	6	11	5	3	1	4	2	5	11	7	24	21	12	21
90–80	31	3	11	1	6	5	13	0	4	9	16	12	6	22	13	9	23
80–70	14	5	4	4	6	8	14	9	8	11	10	18	10	27	24	22	7
70–60	9	3	3	0	2	0	3	0	1	2	3	4	1	8	8	3	1
60–50	11	6	1	2	1	6	1	3	8	7	2	6	8	10	7	2	13
50–40	2	3	7	2	0	9	10	13	19	12	3	11	13	15	21	16	29
40–30	15	3	1	1	0	2	2	6	9	0	2	8	3	9	8	8	5
30–20	6	0	2	1	0	4	2	15	12	5	3	10	6	14	9	7	4
20–10	4	1	0	0	0	1	0	6	7	0	0	1	4	8	6	2	1
10–0	2	0	0	0	0	0	0	5	2	2	0	2	0	3	2	2	0
— 0–10	3	2	4	0	1	1	1	2	1	0	0	1	2	1	0	2	4
— 10–20	0	2	4	0	0	1	0	2	0	2	0	2	1	2	7	2	0
— 20–30	1	0	3	0	0	0	0	2	0	0	0	1	2	0	0	0	0
— 30–40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
— 40–30	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0

TABLE XIV

TABLE OF FREQUENCY FOR NUMBER OF WORDS REPRODUCED

Immediate Recall

	Columbia		U. and C.		F. C. T.		Waynesboro		Columbia[1]	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
Subjects	32		84		31	46	33	40	32	11
6 words	10		19		8	11	18	24	10	2
5 words	16		41		6	19	9	10	11	5
4 words	6		23		9	13	5	3	8	4
3 words			1		5	3	0	3	3	0
2 words					3	0	1			0
A.D. in per cent.	8.33		8.73		17.74	10.87	11.61	10.42	12.5	9.09

	One Half Hour Later				Three and One Half Hours Later			
	Royersford				Boyertown			
	High School		Grammar Grades		High School		Grammar Grades	
	M.	F.	M.	F.	M.	F.	M.	F.
Subjects	42	49	64	78	52	44	67	83
6 words	2	2	0	0	2	5	3	12
5 words	8	16	1	7	10	20	13	22
4 words	10	19	9	26	19	9	10	22
3 words	18	7	20	24	13	9	22	15
2 words	4	2	21	16	4	1	12	9
1 word	0	3	11	5	3	0	7	2
No words	0	0	2	0	1	0	0	1
A.D. in per cent.	14.28	13.60	14.58	16.66	14.10	13.26	17.65	19.35

	Four and One Half Hours Later		Six Hours Later		Seven Days Later
	Chambersburg Schools				West Chester Normal
	Grammar Schools		High School		
	M.	F.	M.	F.	F.
Subjects	143	127	84	120	58
6 words	20	18	3	17	5
5 words	38	32	19	41	8
4 words	27	41	22	36	13
3 words	27	22	25	22	11
2 words	21	14	12	4	10
1 word	8	0	3	0	5
No words	2	0	0	0	6
A.D. in per cent.	24	15.49	17.26	15.14	18.38

[1] For this group the order in which the words were presented as stimuli was: pickle, angel, dirt, busy, onion, women. All the other groups have this order with the first two interchanged save Waynesboro which has the 3d and 4th interchanged also.

(Waynesboro) gives averages of 94.6 per cent. and 93.3 per cent. for the girls and boys respectively. There is no marked difference in performance with age (see Table XV.). The high average efficiency of the model school may be partially due to their training or, perhaps, to the changed order of the stimuli, viz., the order: angel, pickle, onion, women, dirt, busy. For all the delayed recall there is a pretty gradual fall in efficiency from the high schools to the lowest grades. The very low averages for the lowest grades may be partially due to the difficulty of spelling and general technique.

It is surprising to find some higher averages in both columns for recall after three and one half, and four and one half hours, than after one half hour. These exceptions to the Ebbinghaus curve may be due, in part, to the possibility of the subjects, having talked or thought over the words during the longer intervals; but it is hardly likely that this is the whole cause for the discrepancy. It would seem more reasonable, perhaps, that as Jaffa indicated (page 6), the apparent gain of memory with time is due to the better readjustment, and not due to any real gain in memory as such. After 7 days, however, there is a decided loss (West Chester).

Similar results have been found by others in testing memory. In a study of the "Development of Imagination in School Children," by presenting memory materials of various types, Colvin (94) found that "recall after 24 hours seems to be as good, on the whole, as immediate recall, when tested by the method of parts retained." Similar exception has been found by Radosswljewitsch (103).

For the number of words remembered, the girls are superior to the boys without exception, for all periods of time; but for index of efficiency there are few exceptions. Several extreme cases with the Boyertown grammar groups reversed the regular sex relation of average efficiency, and the results for the sexes in the Chambersburg grammar grades are hardly comparable, owing to the fact that for practically all the groups tested, the sexes were segregated, and consequently were subject to differences in training. The number of Columbia women is too small to show reliable sex difference for the Columbia students.

Table XVI. shows the average per cent. for order—the first column—of the whole number of words given as stimuli, the second column, of the whole number of words reproduced. Here again the females are superior, as a rule. The close correlation between the two columns of averages is obvious. The groups below the high schools of Chambersburg show the boys superior for order, but, as noted before, this may be due to difference in training. The per cent. of the whole number of answers given shows a few more exceptions as to sex difference.

TABLE XV

GENERAL AVERAGE AND AVERAGE EFFICIENCY (WORDS)

Immediately Afterwards

	Columbia and Ursinus	Columbia	Columbia[2]	
	M. (84)	M. (32)	M. (32)	F. (11)
Average per cent.	82.14	85.41	81.25	80.30
Average efficiency	65.60	70.45	74.18	81.08

	Normal School	Country Teachers		Collegeville H. S.	
	M. (20)	M. (31)	F. (46)	M. (14)	F. (17)
Average per cent.	83.33	72.58	80.43	70.24	79.41
Average efficiency	67.00	53.55	53.36	65.35	77.71

	Model School[2]		Waynesboro 5–8 gr.		Collegeville and Waynesboro (Subjects Knowing)	
	M. (17)	F. (27)	M. (41)	F. (51)	M. (24)	F. (22)
Average per cent.	76.47	86.41	86.58	87.58	93.05	94.69
Average efficiency	73.71	82.74	81.32	77.59		

One Half Hour Afterwards (Royersford)

	11th and 12th		9th, 10th		All H. S.	
	M. (14)	F. (24)	M. (28)	F. (25)	M. (42)	F. (49)
Average per cent.	60.70	64.00	61.31	67.99	61.11	66.67
Average efficiency	66.71	72.04	58.25	63.88	61.07	69.34

	7th and 8th		5th and 6th		All Grammar	
	M. (35)	F. (38)	M. (29)	F. (40)	M. (64)	F. (78)
Average per cent.	42.86	53.48	36.78	52.50	40.10	52.99
Average efficiency	33.26	42.42	33.55	39.35	33.39	40.84

	4th Grade	
	M. (15)	F. (11)
Average per cent.	36.66	42.42
Average efficiency	25.86	38.18

	Three and One Half Hr. (Boyertown)				Six Hours (Chambersburg)	
	High School		5th, 6th, 7th, 8th		High School	
	M. (52)	F. (44)	M. (67)	F. (83)	M. (84)	F. (120)
Average per cent.	60.26	73.86	54.72	67.27	60.12	72.92
Average efficiency	51.24	71.39	61.22	52.73	58.80	69.58

	Four and One Half Hr. (Chambersburg)				Seven Days (West Chester)	
	5th, 6th, 7th, 8th		3d, 4th		Normal School	
	M. (143)	F. (127)	M. (31)	F. (43)	M. (6)	F. (58)
Average per cent.	63.98	69.03	24.19	45.35	36.11	51.72
Average efficiency	62.31	58.27	20.96	42.58	22.33	32.72

GENERAL AVERAGES FOR CHARACTERS

Immediately Afterwards

	Ursinus College		Royersford 3d, 4th, 5th, 6th		Royersford Second Grade	
	M. (14)	F. (11)	M. (20)	F. (36)	M. (15)	F. (12)
First average per cent.	80.94	90.90	66.50	68.80	50.00	51.70
Second average per cent.	80.10	86.80	60.50	69.20	59.3	68.30

[2] Stimulus words were not presented in the regular order in these groups.

In regard to the two types of word-order series used by the Columbia students there is a marked advantage for the series first used. As in Table XIV. there is a gradual fall in efficiency with decrease in age and school experience. In the test with ten characters the same tendency is shown for age and sex difference as in the word test. In the second test, using characters (Table XVI.) a few groups are shown where the per cent. produced is less than that for the first test. As no directions were given about order in the character test, no figures were computed for efficiency. Table XVII. gives a comparison of the results of Royersford schools after three months (secondary Aussage) with those of one half hour (primary Aussage), a close correlation is found between the averages for recall. The female superiority seems to be more pronounced after three months than after one half hour. The number of cases in the tables will show that a few subjects had been transferred in the meanwhile, from one grade to another, and the number who took the test the first time was not quite entire for the second test, owing to the absence of a few children from school. For the higher grades in recall, more of the boys' answers are correct but the girls give more answers, while for the lower grades the opposite tendencies obtained.

Two facts are clearly shown in the results thus far:

1. There is a gradual increase in efficiency with age.

2. The females are superior to the males for both content and order.

Whipple's "Tests" (pp. 374–384) gives tables from Smedley, Winch, Schuyten, Wissler, Pohlmann, Jacobs, Ebbinghaus, and Norsworthy, which show that memory increases in general, "from the early to the later school years."

The investigations of Kirkpatrick, Bolton, Calkins, Schuyten, and Pohlmann all agree in showing the girls superior to the boys and women to men, in tests of immediate and delayed recall. Lobsien found that girls reproduced more, but that boys were more apt to get the order correct. "Wissler's tabulation of Freshmen tests at Columbia and Barnard College reveal sex difference in memory span for digits that are less than the P.E. of the average, and that favor the men for auditory and the women for visual series." Whipple (83) gives tables for the above, with references (pp. 375–376). These tables show that the age and sex differences in performances revealed therein take about the same trend as the writer's figures, tabulated in this thesis. It would seem that these fundamental differences are proportionally about the same for incidental memory as for "attentive" memory.

Table XVIII. shows that after three months, certainty was ex-

TABLE XVI

PER CENT. OF CORRECT ORDER OF WORDS

No.	Of Whole Number of Words Presented	Of Whole Number of Words Reproduced	No.	Of Whole Number of Words Presented	Of Whole Number of Words Reproduced
	Columbia University Immediate			Model School[4]	
M. 32[3]	49.48	60.89	M. 17	51.96	68.83
M. 32	43.75	51.22	F. 27	55.55	64.26
	Country Teachers			Waynesboro, 5, 6, 7, 8[5]	
M. 31	34.44	45.92	M. 33	63.13	71.43
F. 46	39.49	46.98	F. 30	58.75	65.58
	Waynesboro (Subjects Knowing) 7th Grade				
M. 24	72.91	78.36			
F. 22	73.48	77.60			
	One Half Hour Afterwards (Royersford)				
	High School			5th, 6th, 7th, and 8th	
M. 42	37.30	61.04	M. 64	21.61	53.89
F. 49	44.22	67.33	F. 78	29.27	55.24
	Three and One Half Hours Afterwards (Boyertown)				
	High School			5th, 6th, 7th, and 8th	
M. 52	34.93	57.97	M. 67	31.09	56.82
F. 44	44.69	60.50	F. 83	42.17	62.67
	Four and One Half Hours Afterwards (Chambersburg)				
	5th, 6th, 7th, and 8th			3d and 4th	
M. 143	41.26	64.48	M. 31	60.69	49.09
F. 127	37.79	54.75	F. 43	27.52	9.66
	Six Hours Afterwards (Chambersburg)				
	High School				
M. 84	39.88	66.33			
F. 120	46.66	64.00			
	Characters				
	Immediately Afterwards				
	Ursinus College			Royersford, 3d, 4th, 5th, 6th	
M. 14	25.39	31.37	M. 20	28.00	42.11
F. 11	25.26	28.88	F. 36	25.00	36.29
	Royersford, Second Grade				
M. 15	30.66	61.33			
F. 12	25.83	50.00			

[3] Order of stimuli—pickle, angel, dirt, busy, onion, women.
[4] Order of stimuli—angel, pickle, onion, women, dirt, busy.
[5] Order of stimuli—angel, pickle, busy, dirt, onion, women.
Others order of stimuli—angel, pickle, dirt, busy, onion, women.

TABLE XVII

COMPARISON OF PRIMARY AND SECONDARY RECALL

Royersford

	Sex	One Half Hour Afterwards: Number Cases	One Half Hour Afterwards: Av. Per Cents.	Three Months Afterwards: Number Cases	Three Months Afterwards: Av. Per Cents.
11th and 12th grades	M.	14	60.71	15	32.22
	F.	24	64.00	23	42.75
9th and 10th grades	M.	28	61.31	25	35.33
	F.	25	67.99	21	42.06
7th and 8th grades	M.	35	42.86	30	26.11
	F.	38	53.48	30	38.33
5th and 6th grades	M.	29	36.78	24	16.66
	F.	40	52.50	39	32.90
4th grade	M.	15	36.66	15	15.55
	F.	11	42.42	13	24.36
All high schools	M.	42	61.11	40	34.16
	F.	49	66.67	44	42.42
All grammar grades (5, 6, 7, 8)	M.	64	40.10	54	21.91
	F.	78	52.99	69	35.26

pressed for about 30 per cent. of the correct answers. A higher per cent. of girls than boys expressed certainty, but the boys show in proportion to their correct answers a higher degree of certainty than

TABLE XVIII

RESULTS FOR CERTAINTY

Three Months Afterwards (Royersford)

	11th and 12th Grades		9th and 10th Grades		7th and 8th Grades	
	M. (15)	F. (23)	M. (25)	F. (21)	M. (30)	F. (30)
Per cent. of correct answers marked "sure"	30	34.06	32.00	34.13	21.11	32.78
Per cent. of those marked "sure," correct (index of reliability)	100	94	93.33	93.62	84	88.60

RESULTS FOR EFFICIENCY

Three Months Afterwards (Royersford)

	11th and 12th		9th and 10th		7th and 8th	
	M. (15)	F. (23)	M. (25)	F. (21)	M. (30)	F. (30)
The per cent. of all answers given that were correct	90.60	89.39	92.98	76.81	82.45	69.69

	5th and 6th		4th	
	M. (24)	F. (39)	M. (15)	F. (13)
The per cent. of all answers given that were correct	60	75.24	70	70.38

the girls. For per cent. of all answers given, the boys are noticeably superior in the high schools and 7th and 8th grades; but the girls are superior in the 5th and 6th grades with practically no difference for the 4th grade. No complete record for certainty was tabulated

TABLE XIX. (*a*)

ORDER OF WORDS

Immediately Afterwards

Columbia University

Males[6] (32)						Males (32)					
1	2	3	4	5	6	1	2	3	4	5	6
29	16	11	8	15	16	27	17	13	7	10	10
3	6	14	10	14	14	1	13	17	12	18	19
32	22	25	18	29	30	28	30	30	19	28	29

Country Teachers

Males (31)						Females (46)					
24	17	11	6	1	3	34	27	21	10	10	7
2	10	13	10	18	20	9	18	19	16	33	28
26	27	24	16	19	23	43	45	40	26	43	35

Model School (Ages 12–15)[7]

Males (17)						Females (27)					
16	13	9	7	5	3	25	23	15	10	9	8
	1	3	6	8	6		3	8	13	16	10
16	14	12	13	13	9	25	26	23	23	25	18

Waynesboro (6th and 7th Grades)[8]

Males (33)						Females (40)					
30	28	16	17	14	20	37	33	17	20	17	17
2	4	14	14	14	2	3	7	21	19	15	8
32	32	30	31	28	22	40	40	38	39	32	25

Waynesboro (Seventh Grade, Sub. Knowing)

Males (24)						Females (22)					
23	21	20	14	13	14	22	20	18	14	12	11
1	3	3	6	7	9		2	3	7	7	9
24	24	23	20	20	23	22	22	21	21	19	20

One Half Hour Afterward (Royersford)

High School

Males (42)						Females (49)					
28	29	21	7	6	3	42	42	29	5	11	3
	4	12	24	18	2	3	4	14	27	13	3
28	33	33	31	24	5	45	46	43	32	24	6

5th, 6th, 7th, and 8th Grades

Males (64)						Females (78)					
33	21	20	2	3	4	60	32	28	9	4	4
5	14	16	25	10	1	9	23	31	30	16	2
35	35	36	27	13	5	69	55	59	39	20	6

Three and One Half Hours Afterwards (Boyertown)

High School

Males (52)						Females (44)					
41	37	18	5	5	3	40	39	22	5	7	5
1	6	16	18	30	8	1	3	12	11	29	21
42	43	34	23	35	11	41	42	34	16	36	26

for recall as all the lower grades did not seem to fully understand the directions.

Primacy and Recency

Table XIX. (*a*) shows that for the individual words reproduced in correct order (first row), there is a fairly gradual falling off for all periods of time from the first to the last word. The words reproduced in correct order (second row), show an opposite tendency, with the exception that the fourth word is reproduced out of order the greatest number of times after one half hour, and the fifth word is uniformly given incorrectly the greatest number of times after three and one half hours. No regularity is shown for the remaining groups, except for the West Chester group which after seven days shows a gradual fall from the second to the last word, in number of times each word was reproduced in wrong order. For the total number of times in which each word was recalled without regard to order (third row), the groups that gave immediate reproduction do not show much preference for primacy or recency, due perhaps to the small number of words presented. No striking superiority for primacy and recency is shown for the group that knew the purpose of the test. The small number of times the fourth word (busy) appeared may be due to its being an abstract word. When the order: "angel," "pickle," "onion," "woman," "dirt," "busy" was given (see S. M. S.) the last word (busy) was lowest and when "busy" was given as the third word (W. grammar) it stands very high in the number of times reproduced, but a little low as compared with "dirt" which appeared where "busy" occurred in the regular order. With the regular order of series used, the total number of times each word was given shows for the Royersford school, after one half hour interval, a fairly gradual fall in efficiency, with the last word surprisingly low.

After three months (Table XIX. (*a*)) primacy still plays an important part, but its influence is not in any proportion to that shown for the same group that gave the primary Aussage after one half hour interval. While "busy" is consistently the lowest, the highest for both sexes of all the grades is shown to be at the fifth word (onion) which stands second lowest in the primary recall. Since the results after three months were the secondary deposition, these results may have been influenced by the first test; but this does not seem to be sufficient reason why the difference should be so pronounced for the one word. It is not known, to be sure, how much the subjects talked about this particular word during the interval; but no such high place was found for "onion" where the groups tested for primary recall had an opportunity to talk of the words

during the recess periods, or at their homes. A more plausible explanation might be found by assuming that "onion" called up more associations during the long intervening time than did any of the other words, and it is likely that these associations appealed to sev-

TABLE XIX. (*a*). (*Continued*)

5th, 6th, 7th, and 8th Grades

Males (67)						Females (83)					
50	33	20	10	10	2	67	53	40	22	17	11
	13	23	14	25	20	3	11	20	29	33	29
50	46	43	24	35	22	70	64	60	51	50	40

Four and One Half Hours Afterwards

Chambersburg, 5th, 6th, 7th, 8th Grades

Males (143)						Females (127)					
112	90	64	32	24	32	107	76	51	18	19	17
3	17	42	40	52	41	7	25	48	45	48	65
115	107	106	72	76	73	114	101	99	63	67	82

Six Hours Afterwards

Chambersburg High School

Males (84)						Females (120)					
70	54	34	17	12	14	109	98	56	29	25	19
2	6	25	17	28	24	2	10	33	44	47	53
72	60	59	34	40	38	111	108	89	73	72	72

Seven Days Afterwards

West Chester Normal

Males (6)						Females (58)					
5	1	0	1	0	0	33	22	12	10	11	6
1	3	1	1	0	0	18	25	23	12	6	2
6	4	1	2	0	0	51	47	35	22	17	8

Total Number of Each Word after Three Months (Royersford)

High School

Males (40)						Females (44)					
12	16	12	7	17	18	18	16	17	10	31	20

5th, 6th, 7th, 8th Grades

Males (54)						Females (69)					
15	11	9	4	18	14	31	31	19	9	28	28

eral of the senses. Kirkpatrick and Calkins found that the reproducibility of different forms of material is not equally affected by a three days interval.

In 1894 Miss Calkins (91*d*), experimenting with a series of from 4 to 7 pairs of colors, nonsense syllables and numerals, first emphasized recency and primacy as very important factors in association.

[6] Order of stimuli—pickle, angel, dirt, busy, onion, women.
[7] Order of stimuli—angel, pickle, onion, women, dirt, busy.
[8] Order of stimuli—angel, pickle, busy, dirt, onion, women.
Others: Order of stimuli—angel, pickle, dirt, busy, onion, women.

Two years later she gave much space to the subject in a Monograph Supplement (No. 2, p. 56, 1896).

TABLE XIX. (*b*)

ORDER OF CHARACTERS

Immediately Afterwards

Ursinus College

Males (14)										Females (11)									
m	l	5	y	r	8	w	k	6	p	m	l	5	y	r	8	w	k	6	p
11	6	6	2	0	4	2	1	0		10	7	5	1	1	1	1	0	0	
1	4	7	9	9	10	10	7	13		1	3	4	10	7	10	10	9	11	
12	10	13	11	9	14	12	8	13		11	10	9	11	8	11	11	9	11	

Royersford, 3d, 4th, 5th, 6th

Males (20)										Females (36)									
17	8	7	1	3	3	8	2	6	1	27	19	17	4	3	5	4	2	6	3
3	7	7	6	11	12	3	4	13	11	7	10	9	15	17	21	17	14	25	23
20	15	14	7	14	15	11	6	19	12	34	29	26	19	20	26	21	16	31	26

Royersford Second Grade

Males (15)										Females (12)									
11	10	7	4	2	3	2	2	4	1	9	8	6	2	2	2	1	1	0	0
	2	1	3	3	3	3	4	6	4	2	3	4	3	4	2	3	3	4	3
11	12	8	7	5	6	5	6	10	5	11	11	10	5	6	4	4	4	4	3

Recall of different members of a 7-term series—Binet and Henri (89).

Place in series	1	2	3	4	5	6	7
Times recalled correctly	143	139	115	111	122	117	140

They concluded that the first and last terms of a series are more liable to be recalled than are the middle terms; that certain terms are often found to have special reproducibility. For example, the word pupitre (desk), though in the middle of the series, was recalled in an unusually large number of cases.

Incorrect Words Given

As a rule the errors consist of omissions and misplacement of terms. Errors of substitution are not common. For immediate reproduction they are very rare but increase with time. By 391 subjects only the following words were substituted: "dirty" (three times), "women" (three times), "pickles," "children," "table," and "place" (once each).

After one half hour interval the incorrect answers of 235 subjects were distributed as follows:

	Females	Males
High school	work	woman (6th)
	when	
	lemon	
	noisy	
Eighth grade	nickel (2d)	dust
	girl	
	woman (6th)	
Seventh grade	however	
	book	
	dirty (3d)	
	pimple	
	work	
Sixth grade	girl	duck (3d)
	nickel	
	dirty	woman (6th)
	woman	
Fifth grade	2 orange	nickel (2d)
	bugle (2d)	vinegar
	tickle	dust (3d)
		woman
Fourth grade	purple (2d)	groom
		grand
		2 woman (6th)

The numerals to the left represent the frequency with which the words so marked occurred; the ordinates, in parenthesis to the right, the order of occurrence. All words so marked indicate resemblance in form or content to the word for which they are substituted. The number of incorrect words given after three months by the same group that produced the above after one half hour interval, increases to 144 words, 81 by the 109 girls, 64 by the 126 boys, making an average of .73 and .51 words respectively for each subject. A few of these words taken at random are given below.

nickel	guard	tomato
syrup	drink	pretzel
kitchen	towel	store
mother	cabbage	white
nurse	red	buy
sky	lady	work
fairy	quince	

While most of these words, such as those in the list previously given, seem to be significant (*i. e.*, words resembling the stimuli), the number of significant words decreases with longer time intervals. It is worthy of note that none of the incorrect words are long ones; very few have more than six letters and most of them have five or less.

It may be that many of the words associated with the stimulus

word at the time it was given were called up instead of the stimulus word. For example, "guard" and "sky" were no doubt associated words called up by the word angel. It is difficult to determine, however, whether they were associated words carried over in memory, or words called forth by the attempt to recall "angel" without ever having been associated at the time "angel" was pronounced in the first test; *i. e.,* they may have been called forth by a process of subliminal association. This statement is based on the assumption that while "angel" was not strong enough in consciousness, its impression on the "fringe of consciousness" may have been such as to call up new associations, or new at least to the extent that they were not called forth when the stimulus word was given, or during the interval between the presentation of the stimulus and the attempt at reproduction. This is illustrated by one's attempt at calling up names he apparently has forgotten. He may call forth many which are similar to the desired name and which may finally suggest it, but which were not associated with the name before.

In line with the above results, Kirkpatrick (98) concluded that when such words as "spool," "thimble," "knife," were pronounced, many subjects at once thought of "thread," "needle," "fork," which are so frequently associated with them.

The frequency with which the incorrect words occurred after three months are as follows:

Females (109)	Males (126)
1 word —45 cases	1 word —26 cases
2 words—11 cases	2 words— 7 cases
3 words— 1 case	3 words— 4 cases
4 words— 1 case	
6 words— 1 case	

The incorrect words given by the remaining groups show the same associative tendency and increase in number with the increased interval of time. It might be stated that Meumann (101) noted in his study of memory for words that omission is the ruling error and that words of similar meaning and relation are frequently substituted (Whipple, p. 373).

Correlation with Time

There is practically no correlation of time used in recalling the words with accuracy of recall (coefficient $= -.09$). The average time for reproduction was 38 seconds. The highest five cases were between 94 and 114 seconds, the lowest five cases between 9.5 and 14.5 seconds, and the 14 cases of central tendency were between 20 and 25 seconds.

TABLE XX

ESTIMATION OF NUMBER OF WORDS

	After One Half Hour					Three Months Later				
Sex	Number Subjects	Number Correct Cases	Mode	Av.	A.D.	Sex	Number Subjects	Number Correct Cases	Mode	Av.	A.D.
				Royersford H. S. Juniors and Seniors							
M.	14	6	5	5.36	.55	M.	15	10	6	6.00	.40
F.	24	10	5–6	5.61	.67	F.	21	20	6	5.95	.09
				Freshmen and Sophomores							
M.	28	14	6	5.67	.58	M.	23	21	6	5.91	.16
F.	25	10	5	5.36	.52	F.	19	15	6	6.53	1.05
				All High Schools							
M.	42	20	6	5.57	.57	M.	38	31	6	5.95	.21
F.	48	20	5	5.48	.56	F.	40	35	6	6.15	.33
				Seventh and Eighth Grades							
M.	35	18	6	5.80	.66	M.	29	24	6	6.26	.31
F.	38	13	5	5.92	.92	F.	28	23	6	6.14	.21
				Fifth and Sixth Grades							
M.	29	13	6	6.76	1.03	M.	19	8	6	6.68	1.42
F.	40	18	6	6.05	.58	F.	35	10	5	6.55	1.45
				All Grammar Grades, 5, 6, 7, 8							
M.	64	31	6	6.23	.83	M.	48	31	6	6.46	.75
F.	78	31	5	5.85	.85	F.	63	34	6	6.37	.81
				Fourth Grade							
M.	14	6	6	6.07	.77	M.	13	5	6	7.15	1.54
F.	11	6	6	6.07	.49	F.	12	7	6	6.83	1.58

Tables of Frequency

All High School

After One Half Hour				Three Months Later			
Males (42)		Females (48)		Males (38)		Females (40)	
Words	Cases	Words	Cases	Words	Cases	Words	Cases
8	1	8	1	8	1	15	1
7	1	7	1	7	1	7	2
6	20	6	20	6	31	6	35
5	19	5	24	5	5	5	2
4	1	4	2				
C.E. = − .43		C.E. = − .52		C.E. = − .05		C.E. = + .23	

All Grammar Grades

Males (64)		Females (78)		Males (48)		Females (63)	
Words	Cases	Words	Cases	Words	Cases	Words	Cases
12	1	10	2	13	1	15	1
10	3	8	3	10	3	10	3
9	1	7	8	8	2	9	1
8	2	6	31	7	6	8	3
7	9	5	34	6	31	7	7
6	31			5	4	6	34
5	15			3	1	5	14
4	2						
C.E. = − .23		C.E. = − .15		C.E. = + .46		C.E. = + .36	

Bigham (87*a*), using numerals, colors, forms, words and syllables, found that the longer the interval the longer the time for recollecting and that the number of errors increases regularly with the time used for recollection, and further that "the quicker the memory is discharged the better is the result." The writer's results certainly agree with the first statement for, in the delayed recall, a number of the subjects were still struggling to recall the words at the end of one and one half minutes which was a longer period than that used by any of the individual subjects for immediate recall. But the correlation of efficiency with speed of recall found by Bigham is hardly comparable with that found by the writer, for in the latter case the surprise was so great that the subject was often bewildered for a few seconds before any response was made.

Number of Words Estimated

Practically all the groups show a tendency to underestimate the number of words (see C.E., Table XX.). Mere inspection will indicate that there is, in general, a gradual rise in the estimation from the highest to the lowest grades, *i. e.,* the lower grades make somewhat more nearly correct estimates than the higher grades. The generally low estimates can be partially attributed to the tendency to select five as the number of words that were given. As might be expected from the larger experience of the higher grades, they are more susceptible to this tendency than the lower grades—the females more so than the males. There is no other appreciable sex difference. A glance at the column for reproduction after three months shows the same gradual rise with age for the number estimated, but suggestibility in reference to the number 5 plays little part. The latter observation may explain in part why the number of words is overestimated, as a rule, after three months. The central tendency uniformly falls at 6 in the secondary deposition, while in the primary, the central tendency for the girls was at 5 and for the boys at 6. The average number of words estimated by the girls of the high school is greater than that for the boys, while in the grades without exception the opposite is true. The variability from the central tendency (see A.D., Table XX.) decreases, in general, with the increase of age.

Introspective Observations, Etc.

When the directions to reproduce the words were given, the subjects' surprise was obvious. The individuals expressed it generally by various exclamations, and subdued and sucking sounds through their teeth were heard from the groups. Reddening of the face and physical discomfort were commonly noticed. The attitude of the

TABLE XX. (*Continued*)

Sex	No. Subjects	No. Correct Cases	Mode	Av.	A.D.
		After Three and One Half Hours			
		Boyerstown High School			
M.	52	26	6	5.89	.58
F.	43	18	5	5.60	.60
		Boyertown, Seventh and Eighth Grades			
M.	37	17	6	5.65	.62
F.	35	22	6	5.57	.43
		Boyertown, Fifth and Sixth Grades			
M.	28	12	6	5.75	.64
F.	48	24	6	5.79	.54
		Boyertown, All Grammar Grades			
M.	65	29	6	5.69	.65
F.	83	46	6	5.69	.49
		After Six Hours			
		Chambersburg High School			
M.	84	35	5	5.61	.70
F.	119	59	6	5.51	.58
		Estimation of Number of Letters			
		Immediately Afterwards			
		Columbia University			
M.	63	35	6	5.55	.57
		Royersford, 3, 4, 5, 6, Grades			
M.	16	5	10	9.31	1.31
F.	28	9	10	8.86	1.43
		Waynesboro Grammar Grades			
M.	25	7	10	9.80	1.48
F.	20	8	10	9.30	.90

children in recall was very interesting. Many buried their faces in their hands; some ran their fingers through their hair or scratched their heads; others rubbed their eyes; many slid about in their seats making aimless movements of the limbs and head. Triumph in recalling was often accompanied by a sudden exclamation, and the facial expression of the children often indicated high emotional states. Introspections from the individual subjects corresponded with their facial expression noted. Many stated that at first they were dazed and then later irritated because they had not observed the words while they wrote them. Some felt that the time was going rapidly and that they would seem stupid. After a few moments struggle the emotion of anger and self-accusation often gave place to pleasurable emotions, when they were able to recall one or more words. A few stated that at first the task seemed impossible. In some cases it was stated that two or three words seemed to flash up at once. Most said, however, that one word "dragged in another."

Great individual difference as to perseverance was shown. Some struggled several minutes, others gave up quickly. Practically all seemed to do their best, because it was generally agreed upon by the subjects that they felt that they ought to be able to do "such an easy thing."

Only a few of the 119 individual subjects were observed to recall the words in the order in which they were reproducing them, *i. e.*, the order in which the words appeared on each subject's paper did not indicate the order in which they were recalled.

Conclusion

To sum up, it was found that the best records for the number of words reproduced and for general efficiency were secured immediately after the stimuli were given, and much better when the subject knew that the words and numerals were to be reproduced than when the memory was incidental. The per cent. of the six words remembered immediately was about the same as that for ten letters and figures. There is practically no age difference between the performance of grammar-school children and college men for immediate recall of the six words, but after an interval of time there is a marked decrease in efficiency from the high schools to the fourth grades. The females are markedly superior to the males for average number of words remembered and for average efficiency; they have a high central tendency; vary more in the high schools and fourth grades; but in the fifth, sixth, seventh and eighth grades, they vary less than the males. The same effect of primacy and recency does not obtain for different intervals of time. In the individual reproduction of words and letters each factor manifests itself; the influence of primacy is expressed in the first two or three words and letters, while that of recency is generally manifest in the last unit of the series only. After the intervals of one half hour to four and one half hours, primacy alone is assertive, but after a longer period of three months, the order of words reproduced is almost reversed.

Omission rather than substitution is the rule of error. The number of words substituted increases with time, and many of the substituted words seem to be an embodiment of the thought that is carried in memory rather than the word. Girls substitute more incorrect words than boys. There is no correlation between the time required in recall and the amount recalled. The number of words was underestimated after one half hour and overestimated after three months.

CHAPTER IV

Letter Square Test

Method and Procedure

Another means for studying incidental memory was devised by using a kind of letter square test (105). These letters appeared in the manner indicated by the figure below. They were printed in the central portion of a highly saturated yellow paper (8 by 5 inches), which was pasted on a thin piece of board. It so happened that the board, which in turn was covered by a light brown paper, projected from beneath the sides of the yellow paper three millimeters on each side. The letters were of a bright red color and the surrounding border was black. The O's which were to be counted in the test were so arranged that in order to count them the observer's eyes had to pass over and examine the other letters also, enough, at least, to be sure that they were not O's. These other letters were so placed that the subject could not easily make a guess at the number of O's. If,

however, the subject knew just where the letters should be skipped it is probable they would not have been perceived at all when the eye moved across them.

As first seen by the subject the whole board was covered by a black cardboard. The subject was told that the experimenter desired him to count some O's, and was shown the size of the O's he might expect to see. Then the writer, turning the back of the board to the observer struck it with his knuckles, saying at the time, "This is a piece of board. To the other side of this board (turning it) is pasted a piece of paper on which are printed a group of capital letters" (the experimenter indicating with a pencil the relative position of the group of letters beneath the cardboard). "When I re-

move the cover you will see the letters. Then begin at the upper left hand corner of the group and count the O's to the right just as you do when you read, and as soon as you have finished look up and tell me. Count them as quickly as you can, but do not count them aloud. Do not point to them with your fingers—just the big O's." The last statement was made because in spite of the previous instructions, a number of subjects were found in the preliminary test who counted the dots of the border for O's. When the experimenter was assured that the subject understood the instructions, he said, "Ready," and then on the signal "Go," he quickly removed the screen with the right hand and manipulated the stop-watch with the left. When the subject indicated that he had counted the O's the experimenter quickly re-covered the letters and recorded the time and the number of O's and asked the following questions: "What other letters did you see? How many lines of letters"? (indicating what he meant by running a pencil across the screen). "How many letters per line? What was the color of the letters? Color of the paper? What else did you see on the page besides the letters? Make what you saw. What color?" The answers were taken after each question by the experimenter and the subject in case he said he did not know was asked to guess. "Any more" was asked concerning the letters.

Such immediate response was made on most of the subjects tested, but a deposition after one and one half hours and seven days respectively was secured, as well as secondary recall, after three months, four months and six months. In the delayed primary deposition the subject had been merely asked to count the O's as quickly as possible, and he was made to believe that the test was then ended. The subject was always told that he did well after each response for the number of O's, at which time the stimuli were re-covered. Then the response was called for after the desired intervals. In the Plainfield schools ten children from a room were tested, and the one and one half hour interval for each room was reckoned from the time at which the fifth person completed the test. The consequent error was small, because the time required for each subject was never over three minutes. Furthermore, no time was lost in securing subjects because there was always one subject stationed in the hall at the door ready to enter as each tested subject passed out. At the desired interval the subjects were provided with the above questions written, and during their answering they were urged by the experimenter to answer every one in full. These questionnaires for the reports after 7 days and 6 months respectively the writter gave to the subjects individually and made special appeal to have all questions answered. But in spite of these precautions complete answers were not always obtained.

The part of the test described was given to all subjects, but added to this were varied forms of tests: In case of a part of the subjects who gave immediate response, another group of letters, after the manner of the above group was presented. It consisted of the six letters (excluding the O's) presented in the first stimuli, distributed by chance among twelve other letters. This second group was the same as the first in respect to size and color. The subject was asked to name the letters he recognized as having been seen by him in the previous test. Then he was asked if he recognized anything else. No time limit was set. The subject was then told that he would be given the same test that he had at first—to count the O's of the same group he had formerly received; that it was necessary to do it quickly; that as soon as he had counted the O's he should begin again and count the other letters and try to remember how many of each letter there were. The time for his counting was recorded, and upon the subject's signal of completing the task, the letters were again covered and the subject was asked to reproduce all he saw in exactly the same manner in which he saw them. He had no idea that this was the task awaiting him when he counted the letters. Then the subject was allowed to check up his results with the original stimuli and was made to believe that the test was ended. Before he left off looking at the stimuli, his attention was called to the border. The letters were then covered again and the subject was asked to reproduce the dots in exactly the same manner as to number and distance apart as he thought they were in the stimuli.

The wording of the questions and the mode of procedure was exactly the same for all the respective tests. Each subject was tested in a room apart from any other person except the experimenter, and precautions were so taken that the prospective subjects did not have a chance to be previously informed as to the nature of the test. For the college and the normal school students the experimenter could only appeal to them not to repeat anything about the test to any one; but conditions were such that very little error is probable here as very hearty cooperation was shown by these subjects. In the public schools children were selected by chance, according to the position in which they were seated, in such a manner that no two subjects chosen might communicate with each other.

Added to the above named questions were the following for the secondary recall. "What was the color of the cover over the letters? The paper upon which the letters were written was pasted upon what? For a part of the subjects tested the following were also added: What did Mr. M—— ask you when you first came into the room? Then what did he tell you to do? What did he hold in his

left hand? Did he write with a pen or pencil? How long were you in the room with Mr. M——? Forenoon or afternoon? Was it rainy, clear or cloudy?

In all the secondary recall the subjects were told to underscore those answers about which they were absolutely sure.

Subjects

The subjects tested were 71 men and 12 women of Columbia University, 55 men of Ursinus College, 22 men of a normal school, 20 country school children from 9 to 17 years of age—10 girls and 10 boys; 80 children of the 5th, 6th and 7th grades of Plainfield (N. J.) schools, an equal number of girls and boys; 80 children—40 girls and 40 boys—of the Royersford schools, distributed among the grades from the third to the tenth inclusive, with five girls and five boys from each grade; 62 children of the Collegeville schools distributed as follows: 6 girls and 6 boys from each of the third and fourth grades, fifth and sixth grades, and seventh and eighth grades, and 16 girls and 10 boys of the high school.

Results

The results of this test have been so complex that space can afford only a general presentation of them. Table XXI. gives the result of the first part of the test. The first column gives the record for Columbia, Ursinus and normal school students, and the next four columns give those of the several grades of the Royersford and Collegeville combined without regard to sex. The records for the Royersford subjects are given in regard to sex, in the next two columns. Thus far the figures indicate the reproduction immediately after the stimuli were presented. The results after one and one half hours are shown under those of Plainfield, and the last column shows the results for Columbia students after a week's interval. The figures in parenthesis, at the top of the columns, indicate the number of subjects. The average and median time and the A.D. were determined for all groups. The number of cases where each of the correct letters were stated, the table of frequency for correct letters, the per cent. correct of the whole number of correct stimuli letters, that of the whole number of letters answered, and the general efficiency are next shown. These are followed by frequency tables for the incorrect letters answered. The next two groups of records show the central tendency, average, average error and constant error for the number of lines and number of letters. Then appear the colors assigned to letters, paper, border and the screen, along with the former border indicated.

The tables (*a*) show that the time used in counting the O's increases as age decreases, with practically no sex difference. The average and median are very nearly the same. The lowest grades show a much higher variability than the higher grades, but the decrease in variability is not constant with the increase of age. The girls are slightly less variable than the boys. Twenty-five of the subjects of column one fall at four seconds, and 50 per cent. of the whole number fall between four and five seconds. The order of frequency (*b*) with which the correct letters were recalled is practically the same by all groups for immediate reproduction, namely: X, K, I, P, A, E. How much these answers for correct letters are due to relative legibility of the letters, how much to position and how much to sheer memory the writer does not know. The comparatively high number for "A" by the third and fourth grades may be due to the children's greater familiarity with this letter. A higher proportion of the cases answering after one and one half hours recalled "X" than those for immediate recall; but the other letters stand low, and after an interval of a week the number of times each correct letter is recalled is surprisingly low, and no one letter predominates. Of all the 390 subjects tested, not one recalled the six correct letters; only one recalled five, and six recalled four. On the average, about one subject out of seven could recall none of the correct letters. Of course it is not known how many were really seen. These figures show how one's interests when strongly centered about one thing tend to exclude all else from consciousness. It is obvious that the position of the correct letters was such that the subject in counting the O's had to get enough sensation from the other letters for them to be perceived as not O's. For example, the subject's assurance that "A" was not "O," did not necessarily give him any definite information about the character of the letter A. Hence this experiment may be considered one of incidental perception rather than of incidental memory.

The per cent. of correct letters reproduced (*d*) is highest for the college groups. It is almost as good for the grades after one and one half hours interval as for immediate recall; but only about half as high after 7 days. However, the per cent. of the whole number correct noticeably decreases with time, and as is shown by the number of incorrect letters given, those answering after one and one half hours give more incorrect answers than for immediate recall. The per cent. for efficiency was computed from the following formula used by Strong (105 *b*) in studying "recognition memory":

$$E = \frac{C}{T} \times \frac{C - W}{C + W},$$

TABLE XXI

General Results (Primary Recall)

		Immediately Afterwards							1½ Hours Later		1 Week Later
				Royersford and Collegeville			Royersford		Plainfield		Columbia
		C., U. and S. (148)	H. S. (46)	7 and 8 (32)	5 and 6 (32)	3 and 4 (32)	Boys (40)	Girls (40)	5, 6, 7 (40)	5, 6, 7 (40)	(20)
		M.	M. and F.	M. and F.	M. and F.	M. and F.	M.	F.	M.	F.	M.
(a)	Time Med.	4.1	4.7	4.8	5.3	7.2	5.0	5.1	5.3	5.3	3.5
	Time Ave.	4.5	5.1	5.0	5.5	8.2	5.9	5.7	5.8	6.3	3.9
	Time A.D.	1.0	1.0	.7	.9	2.4	1.4	1.4	1.7	1.1	.7
(b)	Letters correct *X*	71	16	12	17	20	15	16	27	30	3
	K	59	15	12	11	2	14	10	00	2	2
	I	57	11	7	6	2	5	6	2	2	2
	P	36	5	6	2	2	2	8	6	3	1
	A	25	9	6	2	8	4	4	4	9	3
	E	8	5	3	1	3	1	7	5	2	1
(c)	Frequency 5 letters	1	0	0	0	0	0	0	0	0	0
	4 letters	5	1	0	0	0	0	0	0	0	0
	3 letters	28	4	3	1	1	1	3	2	3	1
	2 letters	52	15	10	9	7	9	10	9	5	1
	1 letter	43	15	17	18	20	20	22	24	25	7
	0 letters	19	11	2	4	4	10	5	5	7	8
(d)	Per cent. *C/T*	28.8	22.1	23.9	20.5	19.3	17.1	21.2	18.3	20.0	10.0
	Per cent. of whole No. ans	83.9	64.9	87.0	75.0	79.5	77.4	80.9	58.7	64.9	48.0
	Per cent. efficiency	19.6	19.3	14.7	37.5	45.7	13.6	16.9	14.3	15.0	5.4
(e)	Frequency of incorrect letters										
	6 letters								1		
	5 letters										1
	4 letters								1		
	3 letters	3	3		1	1	0	2	2	3	1
	2 letters	3	5	1	2	1	4	1	7	6	2
	1 letter	34	14	9	6	5	8	9	1	5	1
	0 letters	108	14	22	23	25	28	28	28	26	7
(f)	Frequency No. O's 2d time 15								1		
	14								2	2	
	13								9	5	2
	12								23	30	15
	11								1	3	2
	10								3	0	1
	8								1		

E = efficiency, C = correct answers, W = wrong answers and T = total stimuli. Since the question, "What other letters did you see?" required a selection from a definite number of 26 letters only 6 of which could be correct, the chances stood as 6 to 20 or .3 to 1. Therefore the formula as applied is

$$E = \frac{C}{T} \times \frac{C - W \times .3}{C + W \times .3}.$$

In the case of the recognition test, reported below, the chances were 6 to 12 and the "W" was multiplied by .5 instead of .3. The efficiency for most groups was consistent with the other per cents. but for the 3d, 4th, 5th and 6th grades it was comparatively high (d). This was due to the small number of incorrect answers given in this group as compared with those given in the higher grades. The generally low efficiency for all the groups shows that when chance is discounted there were but few of the letters recalled—about one out of six. For the per cents. of c/T, of whole number of answers and of efficiency (Table XXI. (d)) the girls are superior to the boys in both the Plainfield schools after one and one half hours and the Royersford schools immediately afterwards.

It is obvious that, as in the word test, the tendency was to omit rather than substitute, and the number of incorrect answers increased with time. Substitution was much greater for the letters, however, than it had been for words. Aside from the extreme cases for delayed recall only a few subjects gave as many as three incorrect letters, and not many gave more than one. About 70 per cent. of the cases reporting immediately, and 60 per cent. of the delayed cases, gave no incorrect answers for letters.

The number of O's recalled after intervals of one and one half hours and 7 days, respectively, are shown in Table XXI. (f). Thirty-nine of the 40 boys, 39 of the 40 girls and 17 of the Columbia students gave the same number of O's the second time that they gave the first time. This shows the great advantage of concentrated attention over that which is incidental.

All groups show a pronounced mode at four lines (g); about half of the subjects estimated the number of lines at 4. With one exception the C.T. for immediate recall is at 5 letters per line, and for delayed recall it is at 6 letters (h). The average, A.E. and C.E. are about the same for all the groups, for the number of lines and number of letters per line, with the exception of those after 7 days. Hence, it seems that the average A.E. and C.E. are not affected by an interval of one and one half hours; but they are greatly increased by a 7-day interval, over the errors of the immediate response. The

TABLE XXI. (*Continued*)

GENERAL RESULTS (PRIMARY RECALL)

		Immediately Afterward							1½ Hr. Aft.		1 Wk. Aft.
				Royersford and Collegeville			Royersford		Plainfield		
		C., U. and S. (148)	H. S. (46)	7 and 8 (32)	5 and 6 (32)	3 and 4 (32)	M. (40)	F. (40)	5, 6, 7 M. (40)	5, 6, 7 F. (40)	Columbia (20)
(*g*)	No. lines Mode[1]	4(76)	4(29)	4(17)	4(17)	4(9)	4(20)	4(21)	4(23)	4(11)	4(7)
	Ave.	4.2	4.4	4.3	4.2	4.4	4.3	4.2	4.3	4.2	4.6
	A.E.	1.2	1.4	1.3	1.2	1.4	1.3	1.3	1.3	1.3	1.6
	C.E.	+1.2	+1.4	+1.3	+1.2	+1.4	+1.3	+1.3	+1.3	+1.3	+1.6
(*h*)	Letters per line Mode	6(58)	5(20)	5(12)	5(16)	5(11)	5(23)	5(14)	6(11)	6(9)	6(6)
	Ave.	5.7	5.6	5.6	5.5	5.2	5.1	5.7	6.2	5.3	8.18
	A.E.	.7	.7	1.3	1.0	1.2	1.2	.9	1.7	1.5	3.2
	C.E.	− .3	− .4	− .3	− .5	− .8	− .9	− .3	+ .2	− .7	+2.2
(*i*)	Color of letters Red	64	16	15	10	9	15	13	11	14	2
	Black	29	8	5	9	13	11	11	9	14	12
	Blue	16	7	2	4	4	6	5	5	5	2
	Purple	13	0	0	0	1	0	0	5	1	2
	Some black, some red	8	5	4	2	2	4	9	3	1	1
(*j*)	Color of paper Yellow	74	27	15	14	20	23	26	22	27	4
	White	42	16	16	15	10	15	12	10	10	12
	Brown	4	0	0	1	2	1	1	3	2	0
	Cream	4	1	1	0	0	1	1	0	0	0
(*k*)	Color of border Black	38	19	17	16	16	10	25			
	Blue	10	6	2	4	1	8	2			
	Red	19	10	4	7	4	9	8			
	Purple	13									
(*l*)	Border Rect. of dots	29	17	12	13	12	13	12	5	2	1
	Rect. of lines	12	13	8	11	10	17	8	6	4	1
	No answer	39	7	9	4	3	6	3	20	19	7
(*m*)	Col. cover Black								34	39	6
	Brown									1	1
	Blue								3		1
(*n*)	Pasted on Cardboard								15	16	6
	Wood								12	10	3

[1] The numbers in parenthesis in this line state the number of individuals who gave the modal answer.

C.E.'s for the number of lines are all positive; and those for the number of letters per line are negative, save for delayed recall. This shows that the number of lines was overestimated and the number of letters underestimated, or a tendency at "squaring up" the group was shown. There is no noticeable sex difference.

Not all the colors assigned appear in the tables; only those that were given in more than two cases are recorded. The more mature subjects give a greater variety of colors than the less mature, which may be due in part to greater command of the nomenclature. In addition to the letter-colors given in the table (*i*) the following show the variety of color assigned by the C. U. and S. groups:

2 cases, O's red, others purple	1 case, pink.
3 cases, some blue, some red	1 case, gray.
1 case, some pink, some purple, some blue	1 case, violet.
1 case, some blue, some black	1 case, lavender.
1 case, some blue, some black, some green	1 case, white.
1 case, some blue, some red, some black	1 case, yellow.
1 case, bluish-purple	2 cases, no answer.

For the other color records, as a rule, the colors named in the table exhaust the whole number of colors answered by the several groups. There is less of a variety of colors assigned to the paper than to the letters. The number of units presented in the letters as compared with the integral paper may explain this difference. The answers for the colors of the border are not so various nor are they so numerous as those assigned to the letters. In cases where the border was perceived as a solid rectangular line the "units" may suggest a reason for the comparatively limited variety of colors assigned. It is interesting to note that not a single case of all subjects tested, assigned more than one color to the paper, the border, the screen or to a single letter, *i. e.*, no one said, for example, that part of the paper was of one color and part of the other. But, different colors were frequently assigned to different letters. A number of subjects thought the O's were of one color and that the other letters were of another color. The hypothesis for the explanation of color variety offered above may be logical here. The number of correct colors assigned to the border (*k*) is shown by the figures to be proportionally much higher than the correct answers for the color of the letters. A large number assigned "white" as the color of the paper. Twelve of the C. students after a 7 days interval answered "white" as against 4 who answered "yellow." For nearly all the other groups the correct answers strongly predominate, especially with the C., U. and S. group; however, the number of cases that answer "white" is rather large. This tendency, along with that shown in respect to the

colors recalled for the letters, screen and border, indicates that subjects who do not remember having seen any particular color for the part in question assign a color in terms of their experience. This shows, as Cattell (92) long ago pointed out, that "our perceptions are not copies of a physical world but are mental phenomena dependent upon utility and the whole content of present and past experience."

For the colors there appears no appreciable loss in efficiency after one and one half hours interval, but a decided loss after 7 days. The only noticeable sex difference for color is that for the border, and very likely that is due to chance. For the delayed recall those reporting one and one half hours afterwards give a very good record (91 per cent. correct) for the color of the screen; those after 7 days give only 30 per cent. correct answers. Three answered, "I don't remember" and nine gave no answers. Why the black screen was so well remembered may be because it was a factor that stood in the subject's way when he was eager to see the stimuli beneath.

It will be seen from the variety of the colors assigned to the letters that there are few cases in which the colors represent a fusion; but, as a rule, one of the colors of the apparatus, whether of the screen, the paper, the border or the letters, is assigned to all, or a part, of the letters. The few cases of fusion indicated by the colors answered were due, no doubt, to the moving of the screen. Furthermore, most of the incorrect answers given for any of the colors are the colors of some other part of the apparatus, *i. e.*, the colors are well remembered but incorrectly assigned to respective parts of the stimuli. This has an important educational significance. The traveler and the museum visitor have experiences of this nature. They may have a mass of unclassified knowledge which consequently, for the time at least, may be useless knowledge.

Table XXI. (*l*) shows, for the border, a small number of correct or approximately correct answers by the C., U. and S. group. Only 29 of the 80 who answered for the border indicated it as a rectangle with dotted sides. A somewhat higher proportion is shown for the high school than for the grades in immediate recall. There is a rapid falling off almost to zero efficiency for the delayed recall of the border; especially is this true for the color of the border, where practically no answers were given. A description of the various types of border assigned in immediate recall by the C., U. and S. group is given below:

29 cases, rectangle of dots.
12 cases, rectangle of solid lines.
4 cases, rectangle of dashes.
3 cases, rectangle of small x's.

One case of each of the following:
"Solid black line beneath the group.

2 cases, rectangle of wavy lines.
2 cases, rectangle of pluses (+'s).
1 case, rectangle of stars.
1 case, rectangle of wavy double lines.
1 case, rectangle of x's, dots and circles.
1 case, rectangle of solid lines inclosing dots.
1 case, double rectangle of dots.
1 case, checkered rectangles inclosing each letter.
3 cases, "three black dots."
1 case, "some black dots."
2 cases, "black dotted lines along the bottom."
3 cases, "dots between letters."
1 case, "three blue horizontal parallel lines."
1 case, four horizontal parallel lines, one dotted, one solid.
69 cases, no answers.
Red dots at the bottom of each line.
Two dots.
Dots at the end of each line.
One solid blue line on the left.
Irregularly scattered quotation marks.
Red dots scattered between the letters.
First and last line of letters underscored by solid lines.
Dots variously distributed."
A solid rectangle inclosing four horizontal lines.

Note.—Some merely described the border, refusing to try to reproduce it.

The small number who said the paper was pasted on wood (*n*) as compared with those who answered "cardboard" is another evidence of perception in terms of experience and utility. The records for the remaining groups—Columbia women, normal school students and the rural groups—are not mentioned in the tables, as they do not give anything sufficiently different from the above results to warrant space; but they strongly corroborate the general results of the other groups.

All the Ursinus, normal schools, rural school and 60 of the 71 Columbia subjects were tested for their reproduction of the whole group of letters. Only the results for the C. and U. group are given in the table (XXII. *a*), but the omitted records fall in line with the above results, especially those of the U. group. There is some deviation from the C. group, however, because, prior to the reproduction of the letter square this group was given the recognition test in addition to the test made on all the other groups. The average time (not given in the table) required for the second counting of the O's, together with the counting of the other letters was 9.6 seconds, and median 9.6 seconds, which is a little more than twice the time for counting the O's the first time. The longest time used was 20 seconds, the shortest 4.6 seconds. Seventy-five per cent. of the cases fall between 12 and 6 seconds. In the table the number of O's, number of lines, and number of letters are given for the primary (first) and the secondary (second) report. It is obvious that, while for the first test the C. and U. groups are on a par, the C. group in the second test shows a better record than the U. group for practically all

TABLE XXII. (*a*)

A Comparison of Results of First and Second Tests

	Ursinus College (55)							Columbia University (60)						
	O's		Lines		Letters		Total	O's		Lines		Letters		Total
	1st	2d	1st	2d	1st	2d	Letters	1st	2d	1st	2d	1st	2d	Letters
Mode	12(40)	13(20)	4(30)	4(42)	5(23)	5(29)	20(21)	12(56)	12(39)	4(34)	3(34)	5(18)	6(27)	18(24)
Range	14–9	24–8	6–3	5–3	8–4	7–4	30–12	14–4	17–5	7–3	5–3	8–4	6–3	25–13
Average	11.9	13.0	4.1	3.8	5.5	5.2	19.7	11.7	11.6	4.3	3.7	5.8	5.1	18.1
No. cases correct	40	21	10	12	21	15	10	56	39	12	34	27	27	24
A.E.	.9	1.9	1.1	.8	.7	.9	2.8	.4	.8	1.3	.5	.8	.9	1.9
C.E.	0.0	+ 1.0	+ 1.1	+ .8	− .4	− .9	+ 1.7	− .2	− .4	+ 1.3	+ .5	− .1	+ .9	+ .2
A.D.	.4	1.9	.5	.5	.8	.5	2.4	.4	.8	.7	.5	.8		1.3
Cases of 2d same as 1st		20		36		26			34		23		27	
Cases 2d above 1st		27		3		7			13		4		7	
Cases 2d below 1st		8		16		22			3		33		11	

TABLE XXII. (*b*)

		Ursinus (55)		Columbia (71)	Columbia (60)		
		1st	2d	1st	2d	Recognition	Frequency for Columbia (2d)
X		27	67	39	75	45	6 *X* − 1 case
K		21	51	28	54	27	4 *X* 1 case
I		18	34(28)	28	38(17)	30	3 *X* 3 cases
P		20	50	15	42	16	2 *X* 5 cases
A		9	54	10	45	14	1 *X* 46 cases
E		4	25	1	39	8	3 *K* 1 case
Correct letters	6		3		16		2 *K* 5 cases
Correct letters	5		20	1	13		1 *K* 41 cases
Correct letters	4	3	20	2	17	3	2 *A* 2 cases
Correct letters	3	10	7	12	5	17	1 *A* 41 cases
Correct letters	2	19	2	28	6	28	3 *P* 1 case
Correct letters	1	19	3	18	3	21	2 *P* 1 case
Correct letters	0	4		10		2	1 *P* 37 cases
Per cent *C*/*T*		30	86.4	28.4	71.1	32.8	2 *E* 3 cases
Per cent. of whole No. ans.		78.5	77.4	75.1	73	71	1 *E* 33 cases
Per cent. efficiency		25.5	72.5	23.9	56.9	21.7	2 *I* 2 cases
							1 *I* 34 cases

The Table reads as follows: "*X* was reported, by the 55 Ursinus subjects, 27 times in the first test and 67 times in the second; and by Columbia subjects (71 of whom took the first test and 60 the second), *X* was reported 39 times in the first test and 75 times in the second."

values. This must be due to the influence of the intervening test (recognition test). Although hardly a subject recognized this intervening test as representing the same number of lines and the same number of letters per line, there must have been an influence by the subliminal association of these elements which at the time of attempted recall were too faint to be brought out, and which were dragged into full consciousness when the subject began to reproduce the group of letters. Several subjects stated that when they began to reproduce the group of letters, it all at once dawned upon them that the second group of letters was exactly the same in form as the first group presented.

The decrease in the number of correct O's in the reproduction, can not be wholly due to forgetting as such, for many of the subjects after they had reproduced the letters with the wrong numbers of O's, when asked if they remembered the number of O's, answered "twelve O's." Others, after they had reproduced the group said, "It looks right but the correct number of O's is not there." Many seemed to be disturbed by the assumption that there were four lines, whereby the number of letters they had counted could not be worked out. For the C. group the O's were distributed as follows:

4 O's per line, 14 cases.
3 O's per line, 14 cases.
2 O's per line, 2 cases.
1 O per line, 30 cases.

All the four-O-per-line cases had three lines and six letters per line. All the three-O-per-line cases had four lines and five letters per line. Almost without exception, all the lines of each group had the same number of letters. Twenty-five cases had four lines and five letters: of the U. group twenty-five cases had four lines and five letters. The respective number of lines and number of letters answered by the individuals of the C. group in the first test, as compared with the number of those reproduced by the same individuals in the third test, are shown by the following examples selected at random:

First Test		Second Test	
Six	lines of 8 letters each.	Four	lines of 5 letters each.
Five	lines of 6 letters each.	Four	lines of 5 letters each.
Three	lines of 8 letters each.	Three	lines of 5 letters each.
Six	lines of 7 letters each.	Three	lines of 5 letters each.
Seven	lines of 5 letters each.	Four	lines of 5 letters each.
Five	lines of 7 letters each.	Four	lines of 6 letters each.
Five	lines of 5 letters each.	Four	lines of 5 letters each.
Four	lines of 8 letters each.	Three	lines of 5 letters each.
Six	lines of 6 letters each.	Five	lines of 5 letters each.
Four	lines of 8 letters each.	Four	lines of 6 letters each.

E. g., the individual who answered "Six lines of eight letters each" in the first test gave "Four lines of five letters each" in the third test. It was found that the extremes were not so great in the third as in the first test. Only one of the 60 cases gave five lines of letters in his reproduction, and only one gave over six letters per line; but it is surprising that so few made correct estimates. Those who estimated the number of lines and letters incorrectly, both in the first and third tests, underestimated more in the third than in the first test. But, in efficiency, the general averages for the third test are greatly raised by the large number of cases with both correct number of lines and correct number of letters by the same subjects. Of the 12 cases that were exactly the same in the first and third tests as to both number of lines and number of letters per line, only four were correct (three of six lines). The number of cases which had, for first and third tests, like number of lines regardless of the number of letters, was twenty-five, of which ten were correct. The same figures for the number of letters were twenty-three and fourteen. The large number of like cases show how a first impression tends to carry over and assert itself in subsequent perceptions.

There is little difference in the proportional number of times each correct letter occurred on the two tests (XXII. *b*). The order is about the same, with a little gain for "*A.*" The number of cases recorded for "I" is comparatively low. It is probable, however, that the manner in which the letter I was written caused some of those intended for "I" to be interpreted by the writer as "1's." The numbers in parenthesis indicate the number of times figure 1 was interpreted to have appeared. The table of frequency (XXII. *b*) shows a very small number who reproduced six correct letters, in spite of the fact that the subject had counted these letters just previously in the first test, and had been told, in the second test, to note each letter. It might be assumed that any individual could immediately name these six letters after counting them, but the test of arranging them in the correct position was such a disturbing factor that the letters tended to drop out of the memory in the attempt at reproduction. Several subjects who voluntarily repeated the six correct letters in correct order with respect to one another were able to reproduce but two or three after they attempted to arrange them in proper relation with the O's. For every case, except three, the letters correctly recalled in the first test were recognized, when presented among other letters in the second test.[1] These three must have been right only by chance in the first test. The large number of like cases indicate that

[1] This recognition test which was given before the regular second test was taken by the Columbia students only.

for the first answers chance plays but a little part, and less, perhaps, than has been accredited to it in the formula used above for computing efficiency. Twenty-one cases gave one or more incorrect letters in the first test, and 34 cases in the recognition test. Of the 21 subjects who gave any incorrect letters for the first test only 5 gave the same incorrect letters in the second (recognition test). Of the 16 remaining cases, 6 gave incorrect answers different from those given by them in the first test, and 10 gave no incorrect answers in the second test.

The column under Recognition gives practically the same order of frequency for the several letters as in the first test, with the greatest gain for "E." The incorrect letters "recognized" most frequently are naturally those that most nearly resemble the correct letters, for example, for the 60 subjects, H occurred 13 times; Z, 9 times; L, 7 times; V, 6 times, and R, 5 times. In the first test this same tendency prevailed but to a less degree. Of the 49 incorrect letters "recalled" by 148 subjects, the most frequent were C, 7 times; H, 5 times; R, 5 times; L, 4 times, and M, 4 times.

Twenty-three of the 60 subjects did not give a border in reproduction (second test), though the experimenter had insisted that each subject should make all he had seen. Nineteen of these 23 subjects did not report even a part of a border in the first recall (first test). So it is likely that the border was not really perceived at all by these 19 subjects, even during the second counting of the letters. Of the 37 who reproduced a border in the second test 30 had all, or part of it in the first report, and 7 had nothing. Only one half of these 30 gave any degree of likeness to the original (stimuli-border) in their drawing. This seems to show that the remaining 15 who saw very imperfect parts of the border in the first test were aided thereby in perceiving the border in the second counting. Small as were these parts they were carried either with or without the subject's intention to fixate them, and thus became the nuclei about which the whole border tended to be constructed. No doubt they were carried over unconsciously and the subject got a glimpse of the border in the second counting, because of their being a key to his interests. This has an educational bearing, because it shows how the smallest details, presented at the proper time, are of great value in determining subsequent perceptions.

Table XXIII. (*a*, *b*) shows the number of cases that estimated the number of O's, lines and letters in the secondary recall, as greater than their estimates for the first response (+ cases); the number who estimated these respective quantities less than they did in the first test (— cases); those whose secondary and primary recall were the

TABLE XXIII. (*a*)

COMPARISON OF PRIMARY AND SECONDARY RECALL

(Lines and Letters)

	Royersford School after 4 Months												Collegeville after 3 Months		
	3d, 4th, 5th, 6th Grades						7th, 8th, 9th, 10th Grades						All Grades		
	Males			Females			Males			Females			Both Sexes		
	O's	Lines	Letr's	O's	Lines	Letr's	O's	Lines	Letr's	O's	Lines	Letr's	O's	Lines	Letr's
No. plus cases	5	8	10	8	10	12	3	15	14	8	15	12	14	25	24
No. minus cases	6	2	1	0	1	1	8	3	1	2	3	3	12	11	9
No. like cases	2	2	1	7	1	0	5	0	2	8	0	3	27	13	13
No. like cases correct	1	0	0	6	0	1	3	0	0	5	0	0	25	0	9
Average	11.7	6.7	7.4	20.6	7.2	8.1	10.6	6	8.1	13.6	6.2	7.0	12	5.3	7.9
Average difference	−.3	+2.0	+2.2	+2.8	+3.6	+2.1	−1.4	+1.4	+2.6	+2.4	+1.6	+1.5	−0.2	+1.4	+2.4

TABLE XXIII. (*b*)

COMPARISON OF PRIMARY AND SECONDARY RECALL

(Colors)

	All Royersford after 4 Months				Ursinus after 6 Months	
	Males		Females		Males	
	Lines	Paper	Lines	Paper	Lines	Paper
Cases same as in first test.	16	17	15	23	7	11
Cases partly the same.	6	0	10	0	4	0
Number of cases different.	10	12	8	10	0	5
Number of "same" cases correct	8	11	3	16	4	7

same; the number of the "same" cases that were correct, and the averages and average differences for all individual records between each primary and secondary deposition. The average difference for all columns, except for the number of O's for the boys, is positive. The positive constant error (average difference) for the number of lines and letters is significant, as is the large number of plus cases (column I.). This means that after three or four months, the number of lines and letters grows larger in memory, which fact is in keeping with the observation noted in the second chapter respecting the growing imagery for the dollar bill.

In reference to correct letters, 14 of the 69 subjects had none the same after four months as in the first test; 21 had part of them the same, 11 had all the same; 7 cases with correct answers the second time had no correct answers the first time, and five of these had no incorrect answers. Thirteen cases answered more the second time than the first time, 7 of whom had no incorrect answers. Fifty-six correct letters which were not given the first time in recall were reproduced by the group the second time. Table XXIV. gives the

TABLE XXIV

CORRECT LETTERS FOR SECONDARY RECALL

	Ursinus College (32)	Royersford (69)		Collegeville (55)
	After 6 Months	After 4 Months		After 3 Months
X	20	23		18
A	14	17		18
P	10	16		5
K	8	9		15
E	7	6		3
I	4	5		7
Frequency				
4 letters	3	6		
3 letters	7	4		
2 letters	11	10		
1 letter	8	20		
0 letter	3	29		
		Males	Females	
Per cent. *C/T*	32.8	19	17.6	20.63
Per cent. of whole number answers	44.7	41.2	47.4	48.2
Per cent. of efficiency	14.7	7.6	8.8	10.5

order in which the correct letters were stated, along with the table of frequency for the correct number of letters. The per cents. of efficiency are also recorded here; that for efficiency proper shows that a very few cases remembered any letters (10 per cent.) after three or six months.

Table XXIII. *b* shows the number of cases that gave the same answers for colors in the second test that they had given in the first test; those who gave a part of the assigned colors the same as in the first test; and those who gave different answers, as well as the number

of "like" answers that were correct. Over half of the colors given in answer to the first test are carried over after three and four months; but only a small fraction after six months, and comparatively few answers concerning color are made after six months. The number of like answers that were false show that there was a memory for some of the previous answers. The complete list for color is given in the table (XXV.). The number of colors assigned to the

TABLE XXV

COLORS SECONDARY RECALL

	Ursinus College (32)	Royersford (55)	
	After 6 Months	After 4 Months	
	Males	Males	Females
Color of Letters			
Red	11	11	5
Black	8	8	11
Some red, some black	7	2	12
Blue	4	3	2
Some black, some blue		4	
Yellow		2	
Some red, some blue	1		1
Some black, some red, some blue		1	
Purple	1		
White		1	1
Dark color			1
Color of Paper			
Yellow	20	15	19
White	7	12	11
Brown	1		1
Green	1	1	
Slate	2		
Blue	1		1
Black		1	1
Color of Screen			
Black	14	18	19
White	6	4	3
Gray	5	1	
Blue	1	4	3
Brown	1	3	1
Yellow	2		2
Green	1	2	
Red			2
Orange			1

letters is greatly limited in range as compared with the list given in the primary recall (page 77). Therefore the foreign and irrelevant drop out with time. The same tendency to assign a correct color of some part of the apparatus used, to the wrong object, was manifest; but not nearly as great a confusion is shown as in the primary recall.

The description and representation of the border after four and six months are worthy of note:

Four Months Afterward Royersford (69)	Six Months Afterward Ursinus (32)
7 cases, rectangle of dots.	14 cases, rectangle of dots.
10 cases, rectangle of solid lines.	11 cases, rectangle of solid lines.
4 cases, rectangle of dashes.	1 case, rectangle of dashes.
6 cases, of various other forms.	6 cases, of various other forms.
42 cases, no answers given.	

Those whose answers above, as well as in the primary recall, are represented by "rectangle," would almost invariably say, before representing the border by drawing, "It is a square." The individual records for Royersford show that, of the 11 who reproduce rectangles of dots or dashes after four months, 8 gave the same as in the immediate responses. Of the 10 "solid" border answers, 3 had answered the same in the first test. In only one case did a rectangular dotted border of the immediate response become a solid border in the secondary response. It will be remembered that the Royersford group had but one chance in which to see the border, while the Ursinus group had three chances, in one of which the attention of the subject was particularly directed to the border. No attempt at measuring the sizes of the borders reproduced in delayed primary recall was made, because there was such a wide individual difference.

Sixty of the 69 subjects of Royersford answered after four months, in regard to the "instructions given" (see page 72), in the following manner: 40 cases, "Count the O's," 2 cases, "Count the O's as quickly as possible," 2 cases, "Look what we could see when he removed the cover." One case of each of the following: "To answer the questions he would ask." "See how many letters in a given time." "To sit still and not to tell any of our friends." "Count the number of O's, not with fingers or aloud." "To count the number of leters." "Note the number of letters, size, colors and so forth." "Not to tell anybody." "Count the number of letters in a few minutes." "Count the number of letters and figures in a few minutes." "Look what figures we could see." "To count the letters on the paper." "To count the O's and see how many colors." "See how many black O's." "To count the O's to the right." "To count just the capital O's." "To look up when I was done." Hence two thirds of the subjects gave the essence of the instructions but none recalled them completely. The remaining answers gave fragments of the instructions and some stated what they actually did rather than what they had been told to do. Only a few cases among all subjects tested gave answers wholly foreign to the real instructions. As in the assignment of the colors to the different parts there is a tendency toward confusion in classification, *i. e.*, the fragmentary facts are generally remembered but wrongly classified.

TABLE XXVI. (*a*)

RESULTS FOR THE BORDER

		Border									Dots		
		Length			Width			Ratio			L	W	R
		1st Mm.	2d Mm.	3d Mm.	1st Mm.	2d Mm.	3d Mm.	1st Mm.	2d Mm.	3d Mm.	3d Mm.	3d Mm.	3d Mm.
Columbia 71 men..	Median	29.4	35.2	33.5	30.6	38.4	35.0	1.00	1.08	1.00	7.5	7.6	1.00
25[9] cases 1st test...	Ave.	31.4	35.3	34.3	32.9	38.0	35.6	1.03	1.06	1.03	8.1	7.9	1.00
35 cases 2d test....	A.E.	8.6	5.7	5.8	5.8	7.7	5.6	.14	.15	.16	1.8	1.6	.15
60 cases 3d test....	C.E.	− 4.6	+ 1.4	− 1.7	− 0.12	+ 5.3	+ 2.7	+ .13	+ .12	+ .12	+ 1.1	− .05	.08
Ursinus.....	Median	31.0	36.4	33.9	30.5	40.2	34.3	1.09	1.12	1.10	6.7	7.1	1.00
16 1st.....	Ave.	31.0	36.7	33.4	34.2	41.7	36.2	1.07	1.16	1.11	7.3	7.5	1.06
29 2d.....	A.E.	8.6	5.8	7.4	7.8	10.3	8.3	.22	.13	.20	1.6	1.9	
55 3d.....	C.E.	− 7.1	+ .2	− 2.7	− 1.2	+ 8.76	+ 3.2	+ .20	+ .12	+ .16	+ .3	− .37	

[9] This means that only 25 of the 71 represented a measurable border in the first test, 35 in the second test and 60 in the third test. Only 60 were given the third test.

TABLE XXVI. (*b*)

BORDER FOR FIRST TEST (ONLY)

	Length			Width			Ratio		
	C., U. and S. Group	Royersford 3, 4, 5, 6 Grades		C., U. and S. Group	Royersford 3, 4, 5, 6 Grades		C., U. and S. Group	Royersford 3–6 Grades	
	M. (53)	M. (14)	F. (15)	M.	M.	F.	M.	M.	F.
Median....	29.5	27.2	29	31.1	32	33	1.06		
Ave.....	30.5	32.0	28	32.0	29.3	31	1.05	.87	1.23
A.E.....	8.0			6.0			.16		
C.E.....	− 5.5			− 1.02			+ .13		
A.D.....	5.5			6.0			.12		

After six months the answers for the 32 college subjects were:

9 cases, "To count the O's."
2 cases, "To count the O's as quickly as possible."
3 cases, "To count how many letters."
3 cases, "Observe everything you see."
3 cases, "Tell what you see."
2 cases, "Observe the number of different letters."
1 case, "Note color, letters and arrangement."
1 case, "Count O's, lines and color."
8 cases, gave no answers.

Only about one third of these state, "Count the number of O's," as against two thirds after four months' interval. There is much less variety of answers here which may be due, in part, to the longer time interval and partly to the subjects' being more mature.

It will be remembered that the 20 Columbia students tested after an interval of 7 days, had not given a primary report in the meanwhile. Consequently their answers are less varied and not disturbed by the questions that followed the counting of the O's, as in the case of the results noted above. Their answers were:

16 cases, "To count the O's."
3 cases, "To count the O's as quickly as possible."
1 case, "Not to tell anybody."

The Plainfield subjects—40 boys and 40 girls—who answered in regard to the instructions one and one half hours after the presentation (primary recall), give a very limited variety of answers, and only about one half of the subjects gave any answers. Thus:

18 girls, "To count the O's."
18 boys, "To count the O's."
2 boys, "Not to tell anybody."

In Table XXVI. are given the median average, A.E. and C.E., for the C. and U. groups with reference to the length, width and ratio of width to the length of the borders for the first, second and third successive tests. It will be recalled that in the first test the subject was asked to reproduce what he had seen besides the letters, in the second test he was asked to reproduce everything he had seen, and in the third test, after his attention had been called to the dots, he was asked to reproduce the border with exact dimensions and number of dots (pp. 67–69). These same estimates are given for the first test (Table XXVI. *b*), by the C., U. and S. groups combined and for the Royersford, third, fourth, fifth and sixth grades with regard to sex. The figures to the right give the estimated number of dots. There is no appreciable difference for age and sex. The values for

the size of the borders increase fairly uniformly under the second test and decrease again in the third, but do not fall as low as the value of the first. For the C. and U. groups under length, the second record is uniformly the better. The C.E. shows a tendency at estimating the length too short the first time, by about 5 millimeters and the second time a little too long, but the third time too short again. For the width the average error shows the second record the poorest, and the C.E. indicates the first width as slightly underestimated, the second as greatly overestimated, and the third overestimated but to a less degree. The uniform increase in the size of the border in the second test may be due to the optical illusion afforded by the inclosed group of letters, because in this test the subjects reproduced the letters and added the border afterwards. The underestimation of the length and the overestimation of the width is in keeping with the results for the stamp. The figures for ratio show little difference for the C. group in the three tests. One case under the first ratio, two cases under the second, ten cases under the third, and, for dots, eighteen cases were found in which the ratio equaled one. The corresponding figures for the U. group are 0, 5 and 18. Therefore, as with the stamp, these records show that some of the subjects who estimated the border as square did not draw it so. The ratio computed was for the width to the length, and not *vice versa* as for the stamp. This plan was followed to facilitate computation, because in most cases the width of the border was estimated as greater than the length. This may be due in part to the vertical illusion, since the length was the vertical side; but it is probable that the three horizontal lines of letters were partly responsible for the illusion.

The answers given by the Royersford schools with regard to the details[1] of the experiments made three months before, which are noted in the results of regular test for secondary deposition, are as follows:

Males (36)	Females (35)
Hand with which the Experimenter Wrote	
24 cases, Right hand (correct).	19 cases, Right hand (correct).
10 cases, Left hand.	16 cases, Left hand.
2 cases, No answer.	
Held in Other Hand	
28 cases, A watch (correct).	21 cases, A watch (correct).
3 cases, A pen.	3 cases, A pen.
1 case, A pencil.	2 cases, A pencil.
2 cases, A cardboard.	3 cases, A cardboard.
2 cases, No answer.	1 case, Paper.
	5 cases, No answer.

[1] See pp. 71–72.

He Wrote With	
29 cases, A pencil (correct).	26 cases, A pencil.
6 cases, A pen.	7 cases, A pen.
1 case, No answer.	2 cases, No answer.
Day of the Week	
3 cases, Thursday (correct).	3 cases, Thursday (correct).
5 cases, Monday.	2 cases, Monday.
2 cases, Tuesday.	11 cases, Tuesday.
8 cases, Wednesday.	7 cases, Wednesday.
3 cases, Friday.	4 cases, Friday.
15 cases, No answer.	8 cases, No answer.
Time of Day	
25 cases, Correct.	27 cases, Correct.
11 cases, No answer.	8 cases, No answer.
Weather	
6 cases, Cloudy (correct).	8 cases, Cloudy (correct).
25 cases, Clear.	26 cases, Clear.
5 cases, No answer.	1 case, Rainy.

There was no difference for grades found in respect to the above answers, but some difference was observed in estimating time, as is shown by the figures below:

Males	Females
High School	
9 Cases	9 Cases
Average, 3.8 minutes.	4.1 minutes.
Median, 3.2 minutes.	3.5 minutes.
Seventh and Eighth Grades	
10 Cases	9 Cases
Average, 5.5 minutes.	7.3 minutes.
Median, 4.0 minutes.	6.2 minutes.
Fifth and Sixth Grades	
9 Cases	7 Cases
Average, 6.9 minutes.	6.4 minutes.
Median, 4.9 minutes.	5.3 minutes.
Third and Fourth Grades	
9 Cases	9 Cases
Average, 5.4 minutes.	8.1 minutes.
Median, 5.0 minutes.	5.3 minutes.
Total	
36 Cases	34 Cases
Average, 5.4 minutes.	6.4 minutes.
Median, 4.6 minutes.	5.4 minutes.

In no case was the time, during which the subject was in the room, over three minutes. The average was about two and one half minutes. Without exception the time is overestimated, and more by the

girls than by the boys. This exaggeration by the girls is in keeping with the results of the previous experiments, where it has been shown that in cases of overestimation, the girls overestimated more than the boys. Answers not recorded above, in regard to what the experimenter first said when the subject first entered the room, what he then said and did, show a great confusion, similar to that found in reference to colors. Facts about the procedure of the experiment were fairly well remembered, but they were about as likely to be answered to one question as to another.

Only a small number of subjects gave an expression of certainty in their answers. The girls of Royersford underscored as sure 137 answers out of 400 answers given; 61 or 44 per cent. of these were correct. The boys underscored 94 out of 390 answers, with 37 or 39 per cent. correct. Hence the girls were sure of more answers than the boys and their index of reliability was higher than for the boys. For the 32 Ursinus students the index of reliability was 50 per cent.; for the 20 Columbia students for primary report after 7 days, it was only 43.6 per cent., and the whole number of their answers for certainty was only 39 of the total 250 answers given. The highest degree of certainty, as well as the highest index of reliability, is expressed for the colors, especially for those of the paper and screen. The index for color was 58 per cent. by the Ursinus group and 52 per cent. by the Royersford group.

The writer observed that the subjects who used the least time in reproducing the group of letters, especially those who were able to reproduce immediately upon signal, remembered the most correct words and added fewer wrong ones; however, there seems to be no way of indicating satisfactorily the correlation in terms of figures, from the fact that often a few seconds passed before the subject could think of anything. Some stated while attempting to reproduce the letters that it was an impossible task. One subject refused to try to reproduce any letters, saying that it could not be done. As in the word test, many accused themselves of being stupid.

Correlation for the C. and U. groups, of the time taken to count the O's, with the answers given for the colors of the letters show that 33 cases whose time was above the average, were correct, as against 17 correct cases with time below the average. Correlation with color-of-paper answers show 30 correct for time above the average, and 25 for time below the average. For border, the respective figures were 42 and 21. These indicate that the longer time of exposure favors the perception of the colors, as might be expected. No correlation was found between the time used in counting the O's and the number of correct letters recalled in the first case ($r = +.003$), nor

was there any correlation of time with school grades as computed for 70 school children of Royersford. No satisfactory method could be devised for correlating intelligence with general efficiency, but some of the best records, as well as some of the poorest were made by subjects with the lowest school grades.

Conclusion

The time of counting the O's decreased with age. On the average, about one other letter was recalled. The number of lines and width of the border were overestimated; the number of letters per line and the length of the border were underestimated. The number of lines and number of letters, as estimated, increased after an interval of a few months. The border was very inaccurately perceived; many failed to observe it, even after the second presentation of the stimuli. As a rule, the number of dots was fairly well estimated. Very few letters were recalled, not many were recognized, and comparatively few were reproduced in the attempt to reconstruct the "letter-square." Hence the perception of an object of sensation, to the extent that it is recognized merely as not being the object sought for, gives no assurance that the incidental elements are perceived with any degree of accuracy. Furthermore, the fact that an object falls within the central field of vision does not insure the perception of the object. No one could reproduce the letter-square. Colors were fairly well remembered but were often assigned to the wrong part of the stimuli. Many records show a tendency to answer in terms of general experience. Errors made in the first perception of the stimuli tended to assert themselves in subsequent perceptions of the same stimuli. The index of certainty was low—about 50 per cent. The girls expressed certainty more frequently, and their index of reliability was higher than that for the boys. Likewise the girls answered with more letters than the boys and their index of efficiency was higher.

CHAPTER V

Further Experiments

1. *The Watch Dial Experiment*

This experiment is, perhaps, more a test of observation than of memory. The subject was asked to represent on a piece of paper the Roman letters as they appear on a watch dial. The F. C. T. and the greater part of the Royersford schools furnished the subjects, as this test was given in conjunction with the "magnitude" tests. The results are given below:

	F. C. T.		R. H. S.		R. 7 and 8		R. 5 and 6		Total	
Subjects	13	23	34	43	24	28	11	25	82	119
Sex	M	F	M	F	M	F	M	F	M	F
"IIII" correct	3	1	5	6	1	1	0	4	9	12
"VI" omitted	2	2	0	4	0	0	0	0	2	6
Letters in correct position	2	6	12	16	5	10	5	10	24	42
Letters in vertical[1] position	3	3	8	6	7	4	2	7	20	20
Letter "V" pointing outward	8	14	14	21	12	14	4	8	38	57

[1] Vertical to the tangent of the circumference at XII.

The total group shows that of 201 subjects only 21 wrote the "IIII" correctly; all others wrote it "IV," and only 8 subjects omitted "VI." Two cases show the "VI" drawn through the circle of the second hand; two subjects drew "III" and "IX" vertically, while they placed the other letters in correct order. About half of the subjects drew the letter "V," with the apex turned outward. The writer will hazard no conclusions as to group, age and sex differences. One can be fairly certain that all the subjects tested had frequently seen a watch dial, yet not one out of ten had observed the manner in which the figures were placed on the dial. Those who had been accustomed to watch dials with Arabic figures would be at a disadvantage, but the failure to omit the "VI" can not be explained thereby. As a matter of fact, very few individuals really know whether their own watch has Arabic or Roman notation unless their attention has been particularly called to the fact. These results seem almost incredible, but they show how few associations we form which we have no need of in our experience.

2. *Test of Events with Their Dates*

Another phase of incidental memory was studied by having dates assigned to events which occurred within the memory of the subject. This test took the following form:

I. Indicate your age and sex, but you may omit your name.
II. Write (in figures) after each of the following statements the year in which each named event occurred:
1. The San Francisco Earthquake.
2. The Assassination of President McKinley.
3. Colonel Roosevelt's return from Africa.
4. Death of King Edward VII.
5. The end of the Russo-Japanese War.
6. The shooting of Mayor Gaynor.
7. The Hudson-Fulton Celebration.
8. The St. Louis Fair.
9. Appearance of Halley's Comet.
10. Explosion of the Battleship Maine.
III. Be sure to answer all the above; in case you do not know the year, make a guess.
IV. Underscore all the answers about which you are absolutely certain.
V. State which of the above you answered by associating them with any event in your own life, or with any other events or circumstances.

Each subject was provided with a copy of the above test, and given all the time he desired in which to answer, so long as he was in the presence of the experimenter. Sixteen men and 25 women of Columbia University, and 37 boys and 51 girls of Royersford High School were tested. The results are given below:

The numerals in the left-hand column refer to the ten events of the test. The next two columns give the per cent. and the number of correct cases; the number of correct and incorrect cases that were represented as absolutely certain were next given, followed by the correct and incorrect answers which were indicated as associated with personal experience. The last column shows the errors in terms of years for the median performer. At the foot of each column are stated the average, average per cent., and index of reliability. For example, by the sixteen Columbia men, an average of 9.3, or 58 per cent., answered correctly; six of the correct answers, or 64 per cent., and 2.7 of the incorrect answers or 40 per cent. were marked "certain"; and 69 per cent. of answers marked "certain" were correct. On the whole, only about one half the events are associated with correct dates by the college students and less than one third by the high school group.

Doubtless there is hardly a person to whom these events are not very familiar. At the time of their occurrence, they were the common subjects of the newspaper, the pulpit, the school and the home; yet familiarity of these events as such did not insure their orientation in time. One does not ordinarily associate his experiences with a date, but is accustomed rather to think in terms of other events. An attempt was made to determine the number of cases in which

TABLE XXVII

Association of Events with Time

Columbia Students

	Correct				Certainty for Answers				Personal Association with Answers				Errors by Median	
	Per Cent.		Number		Correct		Incorrect		Correct		Incorrect		Subject	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
1	25	12	4	3	0	1	6	3	1	1	5	10	+1	+ .93
2	69	28	11	7	4	1	2	5	6	1	3	10	− .14	− .35
3	50	72	8	18	6	6	4	2	4	7	3	1	− .5	− .11
4	69	60	11	15	6	5	3	2	4	5	1	4	− .13	.00
5	12	4	2	1	1	0	5	1	0	0	4	5	+1.5	+2.00
6	87	60	14	15	13	8	0	7	7	9	2	5	0.0	+0.20
7	94	64	15	16	13	11	1	3	8	10	0	7	0.0	0.00
8	56	16	9	4	4	3	0	2	2	3	3	4	− .1	+2.70
9	62	68	10	17	6	12	6	6	4	12	4	7	− .2	− .20
10	56	28	9	7	7	3	0	1	5	1	1	5	− .17	+ .31
Average			9.3	10.3	6	5	2.7	3.2	4.1	4.9	2.6	5.8		
Average per cent			58	41	64	48	40	22	44	47	39	39		
Index of reliability					69	61			61	46				

Royersford High School

1	22	21	8	11	5	5	5	15	0	2	0	7	−0.49	−2.42
2	35	19	13	10	6	8	6	13	0	0	2	8	−0.50	−0.50
3	46	39	17	20	7	12	9	11	0	3	0	4	− .25	− .24
4	46	27	17	14	11	10	7	19	0	3	1	10	− .25	.00
5	14	8	5	4	2	0	4	4	0	0	1	5	− .50	−1.12
6	30	18	11	9	7	8	6	10	0	4	1	3	− .38	− .04
7	22	8	8	4	1	1	11	9	0	0	2	3	−2.75	− .12
8	49	27	18	14	7	8	3	10	3	1	0	5	− .38	.00
9	50	51	19	26	12	23	9	18	2	7	2	6	+ .06	− .08
10	41	25	15	13	10	3	3	2	0	2	1	4	+ .39	− .27
Average			13	12.5	6.8	7.8	6.3	11.1	.5	2.2	1	5.5		
Average per cent			35	25	52	62	26	29	4	18	4	14		
Index of reliability					52	41			33	29				

The numerals in the left-hand column represent the order of the events as used in the test.

other events were used as media for location. (See Table XXVII. under "Personal Associations," and read after the manner of the results for certainty shown above.) However, the results given do not indicate the whole number of such cases, because the writer upon questioning some who did not indicate personal associations discovered that the subjects, in answering, relied almost wholly on the plan of connecting the event with some other event, and finally would, perhaps, hit upon an association that carried with it a date. With the personal associations, great difficulty was met in fixing their time, and quite a number of errors were made, as indicated by the number of incorrect answers with these associations. But for both groups many more of the cases with personal associations were correct than incorrect.

There was an obvious sex difference. Both groups showed the males superior to the females in every case except "The appearance of Halley's Comet" and "Colonel Roosevelt's return from Africa." Perhaps all girls took comparatively more interest in Halley's comet than boys did, and local conditions may account for the other named variation from the masculine superiority by the Columbia students. The averages show 57 per cent. correct answers for the males, 40 per cent. for the females by the Columbia group, and 35 per cent. and 25 per cent. for the males and females respectively of the high school. In both groups the males assigned certainty to far more answers than the females and their index of reliability is higher. The females seem to indicate a few more personal associations than the males, but fewer of these associations accompany correct answers.

There is no strikingly apparent sex difference for the median error, as a whole, but a few differences for individual events obtain. The C. students, as a rule, estimate the events as more recent than the H. S. subjects, and the latter give more extreme errors. The general tendency towards assignment of dates too recent may be partially explained in terms of habits of thinking. Any one is accustomed to think he can remember the more recent events best, and therefore, when he can not call up some familiar event asked for in terms of its year, he tends to conclude that it must have occurred at some rather remote time. Some of the college students said they could locate part of the events by means of the date at which they graduated from a certain school. Most students would have difficulty in locating that date were it not the custom to designate classes in terms of the year of graduation. Subjects whose experience necessitated their spending a certain year or years at one place, and certain years at another, were assisted by such experience; but several subjects not recorded above, whose work has been in one place,

and of a pretty even tenor for a number of years, found considerable difficulty with the test.

3. *Rapid Estimation of the Number of Letters in Words*

Inasmuch as one's own name ought to be very familiar, it was desired to determine how many really know the number of letters in their names. In order to control this experiment it was necessary to give a number of words before the estimation of the subject's name was called for. Accordingly the subject was told that ten words would be pronounced, and that he should write down on paper the figures indicating the number of letters he thought there were in each word, or group of words, as they were pronounced; that he should not try to count them as he would not have time, because they would be pronounced very rapidly. Then the words were given in the following manner, "Washington," "New York," "Wednesday," "Theodore Roosevelt," "America," "Children," "Your name as you write it," "Grandmother," "United States," "School." At the end of the list, the subject was asked to write his name as he had it in mind when he estimated it. The words are such that they offer a test in incidental memory, in spite of the large part which observation plays in this test.

Thirty-five men of Columbia University were tested individually.

The following table shows for each word the number of cases correct, the number of plus cases and minus cases, the A.E. and the C.E.:

Words	Correct Cases	+ Cases	— Cases	A. E.	C. E.
Washington	12	3	2	1.6	— .9
New York	18	11	6	.6	+ .2
Wednesday	2	3	30	1.8	—1.6
Theodore Roosevelt	0	2	33	3.2	—2.8
America	14	16	5	1.3	+1.1
Children	7	19	9	1.3	+ .7
Name	17	13	5	1.4	+1.0
Grandmother	7	8	20	1.9	— .9
United States	9	7	19	2.1	— .8
School	19	6	10	4	—1.0

Only 17 of the 35 subjects estimated the number of letters in their names correctly. Five estimated them too small, the rest too large. On the average the subject's own name was overestimated by one letter. Most of the subjects answered that they visualized the words. "They looked so long," or "I saw them printed in the paper," were common statements by the subjects in answer to the question about how they estimated the number of letters. Several said they "saw" all the words printed except their own name, which was in script. Quite a number said they used some standard word for measurement,

others counted one or two syllables and then estimated the rest accordingly. A few said the words "felt" so long or "sounded" so long.

4. *Incidental Memory for Extent of Motion*

The purpose of this experiment was to study incidental memory as compared with "attentive" memory for extent of motion. The subject was furnished with a pad of unruled paper ($8\frac{1}{2} \times 11$ inches) and a pencil. He was then told that after he had adjusted the blindfolder (a pair of blinded goggles lined and bordered with felt), it was desired that he draw a line as nearly straight as possible. In order to more nearly standardize the test he was told that the movement of the arm should be from the elbow and not from the wrist or fingers; that he could get his bearings before he put on the blindfolder, but could not be guided in the test by the aid of the left hand; that he could draw the line any length he liked, just so the pencil did not sweep beyond the edge of the paper; that he could draw it rapidly or slowly but that he should try hard to draw it straight. As soon as the subject completed the desired length, he was asked unexpectedly to draw another line of exactly the same length. Then he was requested to draw two mutually equal lines of any length he would choose. Introspections were then taken. The subjects tested were 35 men and 21 women of Columbia University. A part of these subjects had been given some of the other tests but methods were used to conceal the purpose of the experiment. Subjects who seemed especially curious were told at the beginning of the test that this experiment, it was hoped, would reveal character differences, similar to those previously studied in handwriting. Only one subject was found who indicated that he had suspected the real purpose of the test.

	First Pair		Second Pair	
	Males	Females	Males	Females
A.E. mm.....	9.4	12	6	6.4
C.E. mm.....	— 5.6	— 2.7	+ 4.5	+ 5.0
A.E. per cent.....	10.7	11	11.5	14.1
C.E. per cent.....	— 5.1	— 1.4	+ 8.6	+ 8.3
Plus cases	14	9	27	15
Minus cases	21	10	8	4
Zero cases	00	2	0	2

The above table shows that the average error in millimeters is much greater by both sexes for the first pair than for the second pair; but when reduced to terms of per cent. of the first line, of each pair, the performance for the first pair is the better. This discrepancy is due in part to the fact that all of the men but 7, and all of the women but 4, show a shorter line for the first one of the second pair, than that chosen for the corresponding line of the first pair.

On the average, the first line of the second pair was 36 millimeters shorter than that of the first, for the men, and 50 millimeters shorter for the women. By the men the average length of the first standard line was 85 millimeters, of the second 49 millimeters; by the women the respective length were 99 millimeters and 49 millimeters. Introspections indicated that it was thought by the subject that he could remember the length of a short line better than that of a longer one. Some noted that they thought they were drawing the second pair of lines much longer than they did. Others said they were not conscious of having chosen a shorter line for the second pair, although their results showed a wide difference.

The C.E. shows that the second line of the first pair was shorter than the standard, and that for the second pair the second line was longer than the standard. This is true for both sexes. Great individual difference prevailed. The length of the standard line chosen for the first pair varied from 20 to 190 millimeters; the error for the first pair varied from +30 to −37 millimeters, the second pair from +26 to −16 millimeters. Incidental memory for extent of motion is evidently about as good as "attentive" memory. However, the records for the two types of memory are hardly comparable as the standard line chosen in each type was different for every individual. Perhaps the purest type of incidental memory is shown by this test, and the value of such memory to one's experience is suggested thereby. Experiments were planned to test the senses of touch, taste and smell with respect to incidental memory, but they have not been completed. Their results, however, would not be essential to this study.

In "Memory for Movement" Woodworth (106) found that, "a movement seems greater in memory than in execution, or, in attempting to reproduce a previous movement the constant error is positive. . . . Long distances were found to be reproduced with greater accuracy than shorter distances." In a report on the "Physical and Mental Measurements of the Students of Columbia University," Cattell and Farrand (93) write: "This experiment . . . in which we required a student to draw twice a line as nearly as he could the same length as a standard line of ten cmm. was made at the beginning of the series. About three quarters of an hour later, when all the tests had been completed he was reminded of the line he had drawn and told to draw from memory a line of the same length." The observer did not know at the time he drew the first lines that he would be asked to remember his first drawing. The A.E. for 21 cases was 7.3 mm. and the C.E. +0.2 mm. These authors conclude: "The error is but slightly greater than in the case of immediate comparison of the lines."

CHAPTER VI

Conclusion

It was found that not one individual out of seven hundred represented the exact size of a dollar bill, and only a few estimated the sizes of the respective coins correctly. Not one in twenty could reproduce six simple words in correct order immediately after writing them, in case they did not know beforehand that these words were to be reproduced. It was a rare exception to find a subject who could represent the Roman figures on a watch dial unless his attention had been previously called to the nature of their arrangement. Fewer than half the subjects tested could associate the correct year with events most familiar to them. About half the individuals tested correctly estimated the number of letters in their own names. The average subject tested by means of the letter square, after counting the O's distributed among six other letters, testified to seeing not more than one of these letters, *i. e.,* while he had to recognize the whole six as not O's he did not perceive more than one as a particular letter.

We either shut out entirely from our senses those things which are not in accord with our interests and prejudices, or we perceive them very imperfectly. We read from the newspaper that which comes within our range of interest; but we may scan lines and pages for some particular fact and in the end know nothing about that which is foreign to the object of our search. In our favorite men and heroes we find the qualities we admire; all other qualities we tend to ignore, or we modify and justify them in terms of our experience. That "we see in people and things what we are looking for" is the epitome of human experience. This tendency of selective perception, the specializing student cultivates when he forms the habit of refusing to perceive that which is foreign to his interests, and, no doubt, his conduct and experience justify some of the recent alarm at over-specialization.

The notion that we forget ofttimes because we want to forget is frequently expressed in common parlance; and the Freudian school maintains that the memory has certain inexplicable tricks whereby it drops out the undesirable. Assuming that we do forget, for example, the names of our close acquaintance whose name is associated with the name of some individual who is repulsive to us, even then the explanation in terms of perception may be as reasonable as the Freudian view. Objects, relations, and events which come into the central

field of our interest tend to call forth many associations connected with our past experience; and the nearer to this central interest the objects of sensation are, the more unified and intense are the associations. If, on the other hand, the objects of sensation are repellant, or uninteresting, we ordinarily fail to form associations in the new experience, and where associations are formed there is a tendency to limit them in number and intensity. Therefore, the name of a person who is attractive to us, may immediately suggest the name of some repellant individual, or call forth certain associations relating to that person. Consequently the chain of such associations may be weak. It frequently occurs in an attempt to recall, that the undesirable name comes up in the association, before the name which is desired. In every experience of this kind there may be other inhibitory forces at work, which weaken the already incomplete chain of associations. Hence, to say that we do not perceive what we do not desire to perceive may be more accurate than to say that we forget what we want to forget.

After an extensive test in which the subjects counted the O's twice and the other letters once in the letter square experiment the total experience of only a small percentage of the subjects tested included the correct number of (3) lines and (6) letters. Errors in perception tended to perpetuate themselves in subsequent perceptions of the same stimuli. Not one out of 400 could reproduce the group of letters in order, and less than a dozen reproduced the six correct letters without regard to order. The answers in relation to colors are very inaccurate. A large number of colors were remembered correctly but frequently assigned to the wrong parts of the stimulus. Many answers were made in terms of utility and experience.

In the case of the test for memory for extent of motion, a totally different process was involved. Here experience and utility seemed to be of little importance, but the process depended upon the more naïve mechanism of the nervous system.

The findings of this study seem to strike a blow at the common assumption that because a person does certain acts or work within a certain system, it necessarily follows that he has an intimate knowledge of the activity or system with which he is identified. For example, the sixth grade teacher may be an expert in her teaching activities, but this fact does not insure her expertness in the capacity of analyzing the problems and existing conditions of sixth grade school work in general. These analyses may best be made by one who is free from the daily routine of teaching.

Furthermore, the results of these experiments emphasize the

statement made in the outset, that one's perceptions are in terms of experience and utility, and that associations are likewise formed and recalled in terms of these factors. Objects and events occurring together are not necessarily called up together, or in their relations, because they occurred together, but only when they are associated in terms of the useful by directly coming into the experience, or by being dragged into the experience while clinging to other nuclei of the subject's interest. This study shows, therefore, how meager is one's memory of the most commonplace objects, relations and events that were not in the central field of interest, or closely attached thereto, when they were presented to the senses. Moreover, one often has a mass of imperfect, fragmentary and unclassified perceptions which, when subsequently joined together in terms of experience, present conclusions that are distorted representations of the original stimuli. The manner in which these fragments are interpreted will depend upon the individual's bias at the time of interpretation as well as his center of interest at the time of his original perception of them.

The average school child does not pursue his lessons because of a passion for learning. He goes to school as a matter of course and may, however, find his work full of interest; but he does not consciously set about to gain information. Most of what he learns comes incidentally. Such information is usually indefinite, and is classified only as it comes within the range of the student's interest, or is artificially classified by school machinery. The school's purpose ought to be to find the child's field of interest, and present stimuli in such a way as to build up a mental content around the central interest. The great mass of incidental memory-content is useless, and may interfere with healthy thought processes in so far as this purpose is ignored. In the process of learning, then, the vital factors are the manner in which the stimuli are represented to the senses and the attitude of the subject at the time of their presentation. It is more important to organize the stimuli in their presentation than to organize subsequently perceptions of chaotic stimuli. Therefore the true aim of education should be to teach the child to study rather than to recite.

In addition to its pedagogical relations this subject has an obvious relation to the judiciary. It seems to be the custom of the court, when evidences conflict, to base the verdict largely on the preponderance of evidence. However, the constant error, as expressed in several experiments of this study, such as is shown in the estimation of sizes, numbers and time, for example, shows that the preponderance of evidence may be quite remote from the truth.

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